DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND SOUTHWEST
INTEGRATED PRODUCT TEAM WEST
2001 JUNIPERO SERRA BOULEVARD, SUITE 600
DALY CITY, CALIFORNIA 94014-1976

IN REPLY REFER TO

Ser 05/273
December 24, 2004

Mr. Phillip A. Ramsey
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, CA 94105

Re: DRAFT FEASIBILITY STUDY, SOLID WASTE MANAGEMENT UNITS 2, 5, 7, AND 18, NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD, CONCORD, CALIFORNIA

Dear Mr. Ramsey,

In accordance with Sections 10.2 (a), 10.3 (b) and 10.7 (b) of the Federal Facility Agreement (FFA), enclosed please find for your review the "Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18; Naval Weapons Station Seal Beach, Detachment Concord" dated December 24, 2004 (draft FS). This draft FS is a primary document and in accordance with Section 10.7 (b) of the FFA, your review is to be completed within sixty (60) calendar days following receipt of the document. Therefore, Agency review comments are requested by Friday, February 25, 2005.

2. If there are any questions regarding the enclosed plan, please contact me at telephone No. 650-746-7451 or Internet e-mail: stephen.f.tyahla@navy.mil.

Sincerely,

Stephen F. Tyahla, P.E., CHMM
Lead Remedial Project Manager

Enclosure
Copy to:
California Department of Toxic Substances Control Region 1 (Attn: Jim Pinasco)
California Regional Water Quality Control Board, SFBAY (Attn: Laurent Meillier)
California Department of Fish and Game (Attn: Frank Gray)
IPT West (Attn: Tony Tactay)
Restoration Advisory Board (RAB) Co-Chair (Attn: Ms. Mary Lou Williams)
RAB Member Chris Boyer
RAB Member Kevin Cornish

Re: DRAFT FEASIBILITY STUDY, SOLID WASTE MANAGEMENT UNITS 2, 5, 7, AND 18, NAVAL WEAPONS STATION SEAL BEACH, DETACHMENT CONCORD, CONCORD, CALIFORNIA

Copy to (continued):
Restoration Advisory Board (RAB) Co-Chair (Attn: Ms. Mary Lou Williams)
RAB Member Chris Boyer
RAB Member Kevin Cornish
RAB Member David Griffith
RAB Member Gregory Glaser
RAB Member Ed McGee
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Tech Law, Inc. (Attn: Jennifer Hollingsworth)
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GENERAL SERVICES ADMINISTRATION
CONTRACT NUMBER GS-10F-0076K
DELIVERY ORDER NUMBER 62474-03-F-4037

Feasibility Study
Solid Waste Management Units 2, 5, 7, and 18

Naval Weapons Station Seal Beach Detachment Concord
Concord, California

GSA.129.005

DRAFT

December 24, 2004

NAVFAC
Naval Facilities Engineering Command

**Department of the Navy
Integrated Product Team, West
Daly City, California**

TETRA TECH, INC.

GENERAL SERVICES ADMINISTRATION Contract No. 10F-0076K
Order No. N62474-03-F-4037
GSA.0129.006

Draft

Feasibility Study
SOLID WASTE MANAGEMENT UNITS 2, 5, 7, AND 18

Naval Weapons Station Seal Beach, Detachment Concord
Concord, California

December 24, 2004

Prepared for

DEPARTMENT OF THE NAVY
Integrated Product Team West
Daly City, California

Prepared by

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John Bosche, P.E., Project Manager

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FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

μg/L	Micrograms per liter
μg/m^3	Micrograms per cubic meter
ARAR	Applicable or relevant and appropriate requirement
AST	Aboveground storage tank
BAAQMD	Bay Area Air Quality Management District
bgs	Below ground surface
Cal/EPA	California Environmental Protection Agency
CCHSD	Contra Costa County Health Services Department
CCR	*California Code of Regulations*
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
cm	Centimeter
COC	Chemical of concern
COD	Chemical oxygen demand
COPC	Chemical of potential concern
COPEC	Chemical of potential ecological concern
CSM	Conceptual site model
DCA	Dichloroethane
DCE	Dichloroethene
DO	Dissolved oxygen
DoD	U.S. Department of Defense
DTSC	California Environmental Protection Agency Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological risk assessment
ESL	Environmental screening level
FRTR	Federal Remediation Technologies Roundtable
FS	Feasibility study
HHRA	Human health risk assessment
HRC	Hydrogen releasing compounds
IRP	Installation restoration program
ISCO	In situ chemical oxidation
LUC	Land use control

MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MNA	Monitored natural attenuation
MPE	Multiphase extraction
msl	Mean sea level
NAVFAC	Naval Facilities Engineering Command
Navy	U.S. Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFESC	Naval Facility Engineering Service Center
NPL	National Priorities List
NWSSBD	Naval Weapons Station Seal Beach Detachment
O&M	Operation and maintenance
ORC	Oxygen-releasing compounds
ORP	Oxygen reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAH	Polynuclear aromatic hydrocarbon
PCE	Tetrachloroethene
PRC	PRC Environmental Management, Inc.
PRG	Preliminary remediation goal
RACER	Remedial Action Cost Engineering and Requirements
RAO	Remedial action objective
RCRA	Resource Conservation and Recovery Act
Redox	Reduction/oxidation
RFA	RCRA facilities assessment
RFACS	RCRA facility assessment confirmation study
RI	Remedial investigation
RTDF	Remediation Technologies Development Forum
SI	Site investigation
SLERA	Screening-level ecological risk assessment
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
SDWA	Safe Drinking Water Act
SWMU	Solid waste management unit
TCA	Trichloroethane
TCE	Trichloroethylene
TCLP	Toxic characteristic leaching procedure
TDS	Total dissolved solids

Tetra Tech	Tetra Tech EM Inc.
TPE	Two-phase extraction
TPH	Total petroleum hydrocarbons
TPH-d	TPH as diesel
TPH-g	TPH as gasoline
TPH-mo	TPH as motor oil
USCS	Unified Soil Classification System
U.S.C.	*United States Code*
UST	Underground storage tank
UV	Ultraviolet
VOC	Volatile organic compound
Water Board	San Francisco Bay Regional Water Quality Control Board
yd^3	Cubic yard
ZVI	Zero-valent iron

EXECUTIVE SUMMARY

Under the direction of the U.S. Department of the Navy (Navy), Integrated Product Team West, Daly City, and in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Tetra Tech EM Inc. (Tetra Tech) has conducted a feasibility study (FS) for Solid Waste Management Units (SWMU) 2, 5, 7, and 18 at Naval Weapons Station Seal Beach, Detachment Concord (NWSSBD Concord). The SWMUs are considered as a single site in the FS.

REMEDIAL INVESTIGATION RESULTS

This FS report was prepared based on the results of a remedial investigation (RI) report (Tetra Tech 2004), which are summarized below:

- Significant unidentified areas of soil contaminated by volatile organic compounds (VOC) do not appear to exist at the site.
- VOCs were, however, detected in groundwater over a wide area of SWMU 2 and 5.
- The source of VOCs detected in groundwater at appears to be a former waste oil tank west of Building IA-12 in SWMU 5 (the source area).
- The qualitative human health risk assessment (HHRA) indicates that maximum concentrations of the chemicals of potential concern (COPC) in groundwater exceed threshold levels of concern. Concentrations of cis-1,2-dichloroethene (DCE), tetrachloroethene (PCE), and trichloroethylene (TCE) exceeded the maximum contaminant levels (MCLs) for drinking water. Concentrations of 1,2-dichloroethane (DCA), benzene, bromodichloromethane, chloroform, PCE, and TCE exceeded the U.S. Environmental Protection Agency (EPA) Region 9 preliminary remediation goals (PRGs) for tap water. No maximum concentration of a COPC in soil exceeded the residential PRG, and no maximum concentration of a COPC in groundwater exceeded the indirect exposure screening levels.
- The qualitative HHRA indicates that significant incremental risks (defined as greater than 1E-06) are associated only with potential exposure to PCE in indoor air under a future residential land-use scenario. This finding also is based on additional evaluation using the California Department of Toxic Substances Control (DTSC)-modified Johnson and Ettinger vapor transport model and site-specific input parameters and assumptions. The potential PCE-related incremental risks are driven by concentrations in soil gas measured at two locations (SG25 and SG31) located immediately adjacent to the former waste oil underground storage tank (UST); however, incremental risks associated with potential exposure to VOCs in indoor air are all less than 1E-06 (and are therefore considered insignificant) under a future industrial land-use scenario. Finally, hazard quotients associated with potential exposure to VOCs in indoor air are less than 1 (and considered insignificant) under both future residential and industrial land-use scenarios.

- A screening-level screening level ecological risk assessment (ERA) was conducted for the site. Chemicals of potential ecological concern (COPECs) in soil and groundwater at the site were found to pose minimal risk to ecological receptors.

The RI recommended a focused FS to evaluate remedial actions for groundwater because concentrations exceed agency threshold screening levels for drinking water. However, groundwater at the site is not currently used a source of drinking water. The RI also recommended that a focused FS evaluate remedial alternatives to address incremental risks associated with potential exposure to indoor air under a future residential land use. Most of the site is not currently in active use. The existing buildings were used for industrial purposes. There are currently no plans for redevelopment or residential development. No significant incremental risks or hazard quotients were identified under the existing industrial land use for direct exposure to soil or vapor intrusion based on soil gas modeling.

SWMUs 2, 5, 7, and 18 were evaluated through a typical FS process, which includes the following basic steps:

- Develop remedial action objectives that specify contaminants and media of concern, exposure pathways, and remediation goals. Remedial action objectives are developed on the basis of applicable or relevant and appropriate requirements (ARAR) and the results of the HHRA and ERA.
- Develop general response actions for each medium to address the remedial action objectives. Consider containment, treatment, removal, or other actions singly or in combination in developing general response actions.
- Identify the volume of each affected medium of concern.
- Identify and screen remedial alternatives and technologies for each general response action to eliminate technologies that technically cannot be implemented or are not cost effective.
- Identify and screen process options for each technology.
- Assemble retained process options into alternatives and screen the alternatives.
- Conduct a detailed analysis of the remaining alternatives identified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) at Title 40 *Code of Federal Regulations* (CFR) § 300.430(e)(9).

Based on the information presented in the RI and the ARARs, remedial action objectives and remedial goals were developed for the FS. Remedial action objectives can be achieved either by reducing concentrations of the chemicals of concern (COC) or eliminating the exposure pathways. This FS evaluation considers alternatives that encompass both approaches.

Remedial Action Objectives

The remedial action objectives are to prevent exposures of future residential receptors to:

- PCE, TCE, and cis-1,2-DCE at concentrations that exceed the California MCLs resulting from the domestic use of groundwater.
- Concentrations of PCE and TCE in soil gas in the source area exceeding site-specific remedial goals. Potential types of exposure include from indoor vapor intrusion for a child or adult resident in a one-story building.

Remedial goals were developed for two exposure pathways: domestic use of groundwater, and indoor vapor intrusion. For the domestic use of groundwater pathway, the California MCLs for groundwater were selected as the remedial goals. For the indoor vapor intrusion pathway, remedial goals were developed for both soil gas and groundwater using screening levels that were based on modeling indoor vapor intrusion. The target concentrations for groundwater to protect the indoor air pathway were set higher than or equivalent to California MCLs. Therefore, the California MCLs were selected as remedial goals for groundwater. The remedial goals for soil gas and groundwater are as follows:

COC	Soil Gas Remedial Goals to Protect Indoor Air Pathway ($\mu g/m^3$)	Selected Remedial Goals for Groundwater ($\mu g/L$)[c]
PCE	4,286 [a]	5
TCE	1,200 [b]	5
1,2-DCE	7,300 [b]	6
Vinyl Chloride	31 [b]	0.5

Notes:

a Based on an exposure scenario of adult or child resident in a one-story residence at SWMUs 2, 5, 7, and 18 (Tetra Tech 2004).

b Based on environmental screening levels (Water Board 2003).

c Based on California State maximum contaminant levels.

COC Chemical of concern

General Response Actions and Technology Screening

Five general response actions were identified for achieving the remedial action objectives at SWMUs 2, 5, 7, and 18: no action, land use controls (LUCs), engineering controls, monitored natural attenuation (MNA), and active remediation. Technologies and process options for these general response actions were identified and subjected to a preliminary screening. Soil vapor extraction (SVE) was the only active soil treatment technology retained from the screening process. Active groundwater treatment technologies retained include air sparging with soil vapor extraction, enhanced bioremediation with hydrogen releasing compounds (HRC), and pump and treat.

A number of specific LUCs were also retained. MNA was rejected based on the long period that would be required to reach remedial goals. Modeling of natural attenuation indicated that more than 250 years would be required to reach remedial goals by natural attenuation processes (Appendix A). Reductive dechlorination does not appear to be taking place at the site.

REMEDIAL ALTERNATIVES

Using the selected active treatment technologies in combination with LUCs, where necessary, the following remedial alternatives were developed:

- Alternative 1 - No action.
- Alternative 2 - Air sparging with SVE for the VOC plume and source area.
- Alternative 3A - Enhanced bioremediation throughout plume where VOC concentrations exceed 5 µg/L, and SVE in the source area.
- Alternative 3B - Enhanced bioremediation of the plume where VOC concentrations exceed 10 µg/L, and SVE in the source area.
- Alternative 4 - Pump and treat of the VOC plume and SVE in the source area.

Each of the alternatives was designed with different combinations of technologies that were expected to affect the total cost of the remedial actions and the time needed to reach the remedial action objectives. The key components of each alternative are presented in the following table.

Key Component	No Action	Alternative 2	Alternative 3A	Alternative 3B	Alternative 4
Air Sparging with SVE		X			
Enhanced Bioremediation			X[a]	X[b]	
Pump and Treat					X
One SVE Well in Source Area			X	X	X
Land Use Controls		X[c]	X[c]	X	X

Notes: Gray-shaded boxes do not include the key component.

a Substrate to enhance bioremediation would be injected throughout the area where concentrations of PCE exceed 5 µg/L.

b Substrate to enhance bioremediation would be injected in the area where concentrations of PCE exceed 10 µg/L.

c Short-term land use controls may be needed during the remediation.

SVE Soil vapor extraction

Alternative 2 provides active groundwater treatment to reduce concentrations of VOCs to remedial goals for drinking water over a total period of 4 years (2 years for treatment followed by 2 years of groundwater monitoring). Alternative 3A provides enhanced biroemendiation throughout the VOC plume to reduce concentrations of VOCs to remedial goals for drinking water within 5 years (3 years for treatment and 2 years for groundwater monitoring). Alternative 3B uses enhanced bioremediation within the main portion of the plume where concentrations exceed 10 µg/L of PCE. It relies on groundwater transport of nutrients and microbes to the downgradient portions of the plume along with natural attenuation to reduce concentrations in groundwater in the downgradient portion of the plume. The estimated time for Alternative 3B to reach remedial goals is 20 years. Alternative 4 uses pump and treat to reduce VOC concentrations throughout the plume. However, the time for Alternative 4 to reach remedial goals for drinking water is 20 years.

No LUCs are needed to protect against indoor vapor intrusion through deed restrictions (a form of LUC) that would require installation of vapor barriers or subslab depressurization systems in current and future buildings where vapor intrusion of COCs pose risk. In light of the length of remediation time, however, LUCs are needed to prevent use of groundwater at the site for drinking water for Alternatives 3B and 4. All of the active remedial alternatives incorporate SVE in the source area to reduce concentrations in soil and soil gas to below remedial goals for residential use. Alternatives 2 and 3A are expected to achieve remedial goals within 4 and 5 years. There are no plans for residential use of the site, and the time for residential reuse to occur would exceed 5 years. All the action-oriented alternatives (2 through 4) are expected to protect potential future residential receptors from inhalation risks because the remedial goals for inhalation will be achieved within less than 5 years.

Each of the alternatives was evaluated against seven of the nine criteria. Based on this evaluation, Alternative 1, no action, provides the lowest degree of protectiveness and is not acceptable. Alternatives 2, 3A, 3B, and 4 would each protect human health, comply with ARARs, and allow unrestricted use of the site at some point in the future. Based on long-term effectiveness and permanence, Alternatives 2 and 3A would be the most protective. Alternatives 3B and 4 may take too long to achieve remedial goals, however.

The costs and remediation time frames for the alternatives are shown in the table below. Alternative 2 would achieve the remedial goals within the shortest time frame but is approximately 2 times the cost of Alternatives 3A and 3B. Alternative 3A is the lowest cost alternative and would achieve the remedial goals within 5 years at a cost of $1.9 million. Alternative 3B is the next lowest cost alternative but would take approximately 20 years to reach remedial goals. Alternative 4 is the highest-cost alternative and would take the longest time to reach remedial goals.

	No Action	**Alternative 2**	**Alternative 3A**	**Alternative 3B**	**Alternative 4**
Remediation Time Frame[a]	>250 years	4 years	5 years	20 years	20 years
Cost (in millions)[b]	$0	$ 4.4	$ 1.9	$ 2.2	$ 12

Note:

a The remediation time frame includes 2 years of groundwater monitoring to confirm that remedial goals have been reached.
b Estimated costs are rounded to two significant figures.

The Navy will use this FS to prepare a proposed plan for public comment. The proposed plan will recommend one of the alternatives identified in this FS. After regulatory and community acceptance have been considered, the Navy will issue a record of decision that sets forth the final remedy selected.

1.0 INTRODUCTION

The U.S. Navy (Navy), Naval Facilities Engineering Command, Integrated Product Team West, Daly City, is conducting a feasibility study (FS) for the vicinity of former Solid Waste Management Units (SWMU) 2, 5, 7, and 18 at the Naval Weapons Station Seal Beach Detachment (NWSSBD) Concord in Concord, California (Figure 1). This FS use the term "the site" to refer to the entire investigation area, which includes SWMUs 2, 5, 7, and 18. The Navy has authorized Tetra Tech EM Inc. (Tetra Tech) to prepare this FS report under General Services Administration Contract No. GS-10F-0076K, Delivery Order No. N62474-03-F-4037, to develop and evaluate remedial alternatives for areas where volatile organic compounds (VOC) were detected at concentrations above established screening criteria.

The Navy previously investigated 24 SWMU sites and documented the results in the report, "Final Report, RCRA Facility Assessment Confirmation Study, Naval Weapons Station Concord, California" (RFACS)(PRC Environmental Management Inc. [PRC] 1997). The RFACS included an investigation of SWMUs 2, 5, 7, and 18, and other nearby SWMU sites. Each SWMU was sampled during the RFACS for contaminants that were likely to have been released. Based on the general nature of operations, the list of potential contaminants at many SWMU sites covered all general classes. Of these, several VOCs were consistently detected in groundwater at SWMUs 2, 5, 7, and 18, resulting in further investigation to identify the sources of the releases as well as to further define the nature and extent of the releases. Total petroleum hydrocarbons (TPH) were also detected in groundwater in certain areas, but will not be addressed in this FS because TPH and petroleum constituents will be dealt with under the Navy's underground storage tank (UST) program. Therefore, this FS is focused on VOCs.

After the RFACS was complete, the Navy prepared a site investigation (SI) work plan (Tetra Tech 1998) and installed groundwater monitoring wells to continue evaluating the extent of VOCs in groundwater at the site. The SI confirmed the presence of VOCs in groundwater, and additional characterization of site conditions was deemed necessary. The Navy presented the results of the SI in a remedial investigation (RI) work plan that also presents the Navy's plan for ongoing investigation of the site (Tetra Tech 2001). The draft final RI report incorporated the results of the soil gas characterization and changes made to address agency comments (Tetra Tech 2004).

This FS is part of ongoing investigations conducted by the Navy in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to address potential or existing contamination at NWSSBD Concord. Under the CERCLA process, the FS is a mechanism for developing, screening, and evaluating in detail alternatives for remedial actions to address risk identified during an RI. In addition, the FS documents risk management decisions made by the stakeholders. As the lead agency, the Navy is working with the U.S. Environmental Protection Agency (EPA) Region 9, the California Environmental Protection Agency (Cal/EPA) Department of Toxic Substances Control (DTSC), and the San Francisco Bay Regional Water Quality Control Board (Water Board) to develop and implement the remedial alternatives in this FS.

This FS report was prepared based on the results of an RI report (Tetra Tech 2004), which recommended that a focused FS be prepared because contaminant concentrations in groundwater at the site exceed agency threshold levels of concern for drinking water. The purpose and objectives of the FS report are described in Section 1.1, and Section 1.2 describes the organization of the report.

1.1 PURPOSE AND OBJECTIVES

The purpose of this FS is to develop and evaluate a range of alternatives that (1) eliminate or reduce human exposures to contaminants in soil and groundwater; (2) minimize the effects of contaminants on the environment; and (3) are feasible, implementable, and cost effective.

This FS report was prepared in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and the EPA "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (EPA 1988).

The iterative CERCLA RI/FS process (1) characterizes threats to human health and the environment posed by hazardous substances released at a site, and (2) evaluates potential remedial alternatives to mitigate those threats. The NCP states that appropriate remediation is defined as a cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of human health, welfare, and the environment. Remedial alternatives evaluated in this FS vary in cost and in the level of protection afforded to human health.

This RI and FS grouped SWMUs 2, 5, 7, and 18 together based on their proximity and similar history of use and operations. Figure 2 shows the locations of the SWMUs. This RI and FS were conducted under the Installation Restoration Program (IRP) regulated under CERCLA (EPA 1988).

The focus of the RI (Tetra Tech 2004) was to define the nature and extent of VOCs consistently detected at concentrations that exceed screening criteria in groundwater monitoring wells at the site. TPH constituents, including benzene, toluene, ethylbenzene, and xylenes at the site, are investigated separately under the Navy's UST program, which is regulated by the Water Board. In an effort to maximize efficiency between the two programs, the Water Board requested supplemental analysis for TPH on selected soil and groundwater samples collected from the site. For this reason, sampling locations that could assist in delineating TPH contamination in other studies were additionally sampled during the RI for TPH as gasoline (TPH-g), TPH as diesel (TPH-d), and TPH as motor oil (TPH-mo). Because the primary focus of the RI was the investigation of potential sources of VOCs, however, sampling locations were distributed across the site to investigate the nature and extent of VOC constituents in soil and groundwater and not of potential TPH contamination. Additionally, natural attenuation parameters were analyzed to provide an initial assessment of potential natural attenuation processes at the site.

The Navy has placed NWSSBD Concord on a reduced operating status; however, the site still retains its military function and will continue to do so for the foreseeable future. Although future residential use of the site is unlikely, the RI used residential screening criteria to add conservatism in the screening evaluation and as criteria for unrestricted future use. Screening criteria used in the human health risk assessment (HHRA) are based on preliminary remedial goals (PRG) promulgated by EPA (EPA 2002); the screening levels for groundwater are based on protection of criteria for residential indoor air (Water Board 2003) and maximum contaminant levels (MCL) and tap water PRGs (EPA 2000, 2002). Maximum detections of VOC constituents were evaluated for the HHRA. Although TPH was not evaluated as part of the HHRA, screening criteria for TPH in soil and groundwater were used to assess the nature and extent of contaminated soil and groundwater.

The FS process of developing and evaluating remedial alternatives consists of the following steps:

- Develop remedial action objectives that specify contaminants and media of concern, exposure pathways, and remediation goals. Remedial action objectives are developed on the basis of applicable or relevant and appropriate requirements (ARAR) and the results of the HHRA and ecological risk assessment (ERA).
- Develop general response actions for each medium to address the remedial action objectives. Consider containment, treatment, removal, or other actions singly or in combination in developing general response actions.
- Identify the volume of each affected medium of concern.
- Identify and screen technologies for each general response action to eliminate technologies that technically cannot be implemented or are not cost-effective.
- Identify and screen process options for each technology.
- Assemble retained process options into alternatives and screen the alternatives.
- Conduct a detailed analysis of the remaining alternatives identified in the NCP at Title 40 *Code of Federal Regulations (*CFR) § 300.430(e)(9).

1.2 REPORT ORGANIZATION

The organization of this report generally follows the suggested format found in the interim final EPA document, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (EPA 1988). Section 2.0 provides a summary of the history of NWSSBD Concord, and the geology and hydrogeology, and the planned future use of the site. Section 3.0 summarizes the RI and the nature and extent of contamination. Section 4.0 summarizes the results of the qualitative human health risk assessment. Section 5.0 summarizes the results of the screening-level ecological risk assessment. Section 6.0 describes the approach for the FS. Section 7.0 presents the FS evaluation, and Section 8.0 presents to conclusions. The text is followed by a list of cited references, figures, and tables. Appendix A contains the modeling input and parameters and results used to evaluate monitored natural attenuation (MNA) as a remedial alternative for SWMUs 2, 5, 7, and 18. Appendix B contains cost estimates for the remedial alternatives.

2.0 SITE DESCRIPTION AND BACKGROUND

The following subsections discuss the site location and description, land use, climate, site history, current and former operations, previous investigations, regional setting, and regional geology and hydrology. A more detailed description is provided in the RI report for SWMUs 2, 5, 7, and 18 (Tetra Tech 2004).

2.1 SITE LOCATION AND DESCRIPTION

NWSSBD Concord is a major naval munitions transport and shipment facility located in the north-central portion of Contra Costa County, California, about 30 miles northeast of San Francisco. The facility encompasses 13,000 acres and is bounded by Suisun Bay to the north and the City of Concord to the south and west (Figure 1). Currently, the facility includes two principal areas: the Tidal Area and the Inland Area (Figure 1). This FS focuses on SWMUs 2, 5, 7, and 18 (Figure 2) in the Inland Area, which is approximately 6,200 acres in size.

Access to the Inland Area is through a guarded gate off the Port Chicago Highway, east of the main entrance to the Tidal Area. Public access is restricted.

The site is located on gently sloping terrain between the hills to the east and Seal Creek to the west. Seal Creek is about 130 to 1,200 feet from the site (Figure 2). The site slopes westward from the hills to the creek roughly parallel to the creek at an approximate grade of 1.25 percent.

2.2 SITE HISTORY

Facilities located in the greater Inland Area of the NWSSBD Concord are mostly nonoperational. These areas were formerly dedicated to ordnance operations. The site is located on the original property of the Naval Magazine, Port Chicago, acquired by the Navy in 1942.

Most operations at NWSSBD Concord currently take place in the Tidal Area. Operations were formerly centered in the Inland Area, however. Ammunition storage in the Inland Area was the largest single land use at NWSSBD Concord. Ammunition was stored in five magazine groups and two groups of barricaded railroad sidings. Support facilities for inspection and maintenance of ordnance were located throughout the Inland Area.

Construction of the waterfront handling facilities began in January 1942, and the facility was commissioned as the Naval Magazine Port Chicago in April 1942. Around this time, the original name was changed from Bay Point to Port Chicago. The Inland Area, located in the Diablo Creek Valley, was subsequently acquired and linked to the Tidal Area by the Port Chicago and Clayton Railroads. In 1963, the base was officially renamed Naval Weapons Station Concord. In April 1998, the base became NWSSDB Concord.

NWSSDB Concord was added to the National Priorities List (that is, it became a Superfund site) on December 16, 1994.

2.3 CURRENT AND FORMER OPERATIONS

NWSSBD Concord is the major naval explosive ordnance transshipment facility on the West Coast. The facility provides storage, maintenance, and technical support for ordnance operations. Although daily operation of the facility has been reduced to a minimum, responsibility for environmental cleanup remains with the Navy into the future.

Personnel at NWSSBD Concord were interviewed during a visit on January 23, 1998, to obtain information on current building uses as well as historical site uses (Pieper 1998). This section and the following subsections summarize information obtained from previous investigations and interviews with NWSSBD Concord personnel.

The site is associated with buildings originally constructed to support operations and maintenance of the Inland Area facilities and vehicles, including base motor pool and locomotives, and is located within the Operations Area of the Inland Area of NWSSBD Concord. A wide variety of operations were conducted in the vicinity of SWMUs 2, 5, 7, and 18. The following subsections discuss operations at the Operations Area and each SWMU, as well as for areas upgradient from the site. Figure 3 shows the locations and primary uses of all buildings in the vicinity of SWMUs 2, 5, 7, and 18 and in the areas upgradient.

2.3.1 Operations Area

Since 1998, when the interviews were conducted, the level of activity in the Inland Area has been vastly reduced, and many structures are no longer used. In 2003, Mr. Amado Andal, who worked at NWSSBD Concord for the U.S. Navy, provided information on past site operations. Figure 3 is based on information provided by Mr. Andal and in the draft environmental baseline survey (CDM Federal Programs Corporation 2003). Figure 3 lists the names and former uses of nearly all buildings in the industrial portion of the Inland Area of NWSSBD Concord.

Changes to the area include demolition of the locomotive turntable and steam-cleaning station southeast of and inside Building IA-51 and construction of a steam cleaning pad, known as Building 269. The locomotive/heavy equipment shop (Building IA-12) and the public works/combined shops (Building IA-15) operated for their original intended purposes for many years; however, the levels of activity in these shops greatly diminished and the buildings are not significantly used at present (Pieper 1998).

According to NWSSBD Concord personnel, chemicals used in the Operations Area were purchased from suppliers in bulk in 55-gallon drums from the early 1940s through the late 1960s in accordance with military specifications. During this period, chemicals were used directly from the drum or were transferred to smaller containers. The types of chemicals used in the Operations Area included paint, paint solvents, automotive and machine cutting coolants, solvents for parts cleaning, and oils and lubricants for machine and automotive maintenance. Wastes generated at these locations included paint, spent paint and machine solvents, waste oil, and oily sludge (Pieper 1998).

In the mid-1970s, NWSSBD Concord began purchasing commercially available chemicals. Most chemicals were purchased in smaller quantities and were used directly from the supply containers. Chemicals needed in larger quantities were purchased in 55-gallon drums from commercial suppliers and were also used directly from the supply containers. Except for automotive antifreeze, there were no significant changes in the types of materials purchased. Glycol-based coolants were phased out of use in the late 1970s or early 1980s (Pieper 1998).

2.3.2 SWMUs 1, 2, 5, 7, 16, and 18

Operations at SWMUs 2, 5, 7, and 18 are the primary areas under consideration, and each is discussed below. Operations at SWMU 1 and 16 are discussed separately in Section 2.3.2.5. SWMU 1 is discussed because it is downgradient from the site, and monitoring wells in this SWMU were used to assess the potential downgradient extent of TPH and VOCs. SWMU 16 is discussed because it is upgradient of the other SWMUs, and contaminated soils were discovered and remediated at SWMU 16. Section 2.4 discusses in detail previous investigations conducted at each SWMU.

2.3.2.1 SWMU 2 – Building IA-7

SWMU 2 is located at the NWSSBD Concord fire department. SWMU 2 consists of Building IA-7, which was constructed in the mid-1940s as a fire station for the Inland Area. Fire department personnel indicate that “red rags” were routinely burned within a drum outdoors (Pieper 1988). The rags, which contained oils and solvents, were handled separately because of the risk of spontaneous combustion. Fire logs from 1965 indicate the red rags were transported from Building IA-38. The rags were burned when they wore out.

Fuel oil and napalm were reportedly burned in a shallow pit south of the fire station (Figure 2) as part of fire-fighting training conducted between 1969 and 1973. Extinguisher chemicals reportedly included potassium chloride, sodium chloride, ammonium phosphate, and potassium carbonate. Between 1969 and 1973, residues of these chemicals were reported to have been scraped off the ground and disposed of in the bed of Seal Creek just south of the fire station.

Since 1973, practice burns were apparently conducted in shallow metal pans at Building IA-7. Chemical residues that remained in the pans were disposed of at approved sites, as reported in the Resource Conservation and Recovery Act (RCRA) facility assessment (RFA) report (DTSC 1992). The source of the described burning and disposal activities in the RFA report is unknown and the reported activities have not been confirmed nor has the Navy discovered additional specific information. The general SWMU area was investigated and sampled in 1997 during the RFACS (PRC 1997) as summarized in Section 2.4 of this report; significant contamination related to the alleged burning and disposal was not discovered (PRC 1997).

A satellite hazardous waste storage area located south of Building IA-7 (Figure 2) consists of a metal shed that housed 55-gallon drums until they were moved to the hazardous waste storage facility at Building 433.

2.3.2.2 SWMU 5 – Buildings IA-12 and 269

SWMU 5 consisted of Buildings IA-12 and 269. Building IA-12 was constructed in the mid-1940s and is in the former main industrial complex of NWSSBD Concord (Figure 2). The building has been cleared of all equipment and is no longer used for any industrial activity. The building housed the locomotive repair shop, where approximately 1,100 pieces of railway, automotive, construction, and weight-handling equipment were maintained. During the 1998 site visit, this building was used for locomotive repair. Aboveground oil supply tanks are located on the south side of the building, and a waste oil sump was located at the northwestern end of the subgrade corridor (PRC 1997). The building was steam cleaned and equipment was removed in 2002 and 2003.

Batteries were maintained and recharged at the northeastern corner of Building IA-12 until 1992. Batteries were stored in a satellite accumulation point on the north side of Building IA-12. Approximately 49 automotive batteries were recycled annually. Approximately 24 locomotive batteries were also recycled at this location before 1997. Battery acids were drained and sent to Mare Island Naval Shipyard for recycling. Battery casings were rinsed and neutralized for recycling. A grease and sand trap is located along the northwest interior wall of Building IA-12.

A 6,000-gallon capacity waste oil UST installed in the mid-1970s was used to store waste oil generated from locomotives. The UST was removed from the south side of Building IA-12 on November 4, 1994, as part of the RCRA closure. This UST was located between the existing oil tank containment area on the western end of the building and the dock on the eastern end of the building. Inspection of the tank when it was removed indicated no visible leakage. Six soil samples were collected from the tank excavation, and total recoverable petroleum hydrocarbons as motor oil were detected at a maximum concentration of 230 milligrams per kilogram (mg/kg). As a result, 35 cubic yards of contaminated soil was excavated for off-site disposal. VOCs; polynuclear aromatic hydrocarbons (PAHs); TPH-d; and benzene, toluene, ethylbenzene, and total xylenes were not detected. Case closure approval for the UST removal was obtained from DTSC in March 1995 (PRC 1997).

Waste was generated and accumulated at various locations around Building IA-12. Stained asphalt was observed at various locations along the northeast and southeast walls of Building IA-12.

Building 269, the locomotive and rail car steam-cleaning facility, is located 60 feet west of Building IA-12. Navy records indicate that the steam-cleaning area was constructed in 1976 to collect oily wastes for processing through an oil-water separator located about 5 feet west of the steam-cleaning area. The present configuration of the steam cleaning pad was constructed in 1995. According to NWSSBD Concord personnel, the 1995 construction involved repair of the cracked concrete pad and installation of a cover that complies with current provisions of the facility's storm water permit. The oil-water separator was a single-walled, 6-inch-thick concrete sump with a 200-gallon capacity measuring about 4 feet wide, 9 feet long, and 7 feet deep. The oil-water separator was also known as Sump Container No. IA-12B. A contractor removed the sump contents annually and cleaned the sump. The oil-water separator was inspected biannually. Water from the oil-water separator discharged to the sanitary sewer (PRC 1997).

2.3.2.3 SWMU 7 – Buildings IA-15 and IA-16

SWMU 7 consists of Buildings IA-15 and IA-16. According to a 1944 floor plan, Building IA-15 included a metals shop, a machine shop, a weld shop, a forge shop, offices, and a tool storage area in the eastern portion of the building and an automotive repair shop at the western end. Sanitary sinks are located in both the weld and forge shops. A sump is located in the southeastern corner of the automotive shop. This sump has been backfilled.

Building IA-16 was the paint shop where maintenance crews staged painting jobs for NWSSBD Concord. By the early 1940s, a crew of approximately 20 painters worked in this building. The crew at the paint shop had been reduced to three painters responsible for touch-up, repair, and minor interior finishing work by 1960, however. Much of the paint used was oil-based. Furthermore, much of the exterior paint was lead-based. Before the 1970s, all waste paint, thinners, and cans were likely disposed of in the Tidal Area Landfill (Installation Restoration Site 1). Paint usage was estimated at 700 gallons per year, generating about three drums of solid waste per year. Major finishing projects are now assigned to contractors, who are also responsible for the cleanup and disposal of their materials.

A paint shop, storage shed, and paint locker are located northeast of Building IA-16. A satellite accumulation area for waste paints and thinners is located near the storage shed northeast of the building. Empty paint cans are allowed to dry and then are disposed of as nonhazardous waste in a municipal trash bin.

Four 11,500-gallon USTs were located beneath the paved area between Buildings IA-16 and IA-12, two gasoline USTs and two diesel USTs. Three of the USTs are adjacent to the southeastern corner of Building IA-16 (the northwest corner of Building IA-17), and the fourth was located off the northwest corner of Building IA-12 (south of Building IA-16). The four USTs were removed in January 1999; a formal report detailing the tank removals was issued in September 1999 (Niccum 1999). Based on observations and confirmation sampling, all contamination was removed at three of the four tanks; however, a small amount of visibly stained soil was left in place at one tank that formerly contained diesel fuel. Access to the residual soil was obstructed by utilities, a railroad track, and the foundation of Building IA-12 (Niccum 1999).

2.3.2.4 SWMU 18 – Building IA-51 and Locomotive Turntable

SWMU 18 consists of Building IA-51 and a locomotive turntable. Building IA-51 was constructed in the 1940s and is located in the main industrial complex. Railroad tracks run east to west along the north and south sides of the building. The railroad tracks are currently used primarily as holding areas for several boxcars. A 40-foot-long splash wall is located 20 feet east of the building.

The building was used as a steam-cleaning facility for locomotives, trucks, and other vehicles, and as a tire maintenance shop. The steam-cleaning facility was deactivated in the mid-1970s when the steam-cleaning facility at Building 269 west of Building IA-12 became operational. Oily waste generated by steam cleaning drained directly into a sump (Container No. IA-51). The oil was pumped out by a contractor, who also periodically cleaned the sump. The former sump was installed in 1945, 12 feet east of the splash wall. The sump is made of concrete 6 inches thick and had a capacity of 40 gallons. Sump Container No. IA-51was filled with concrete when the steam-cleaning unit was deactivated.

Before the early 1960s, a zinc chromate rust inhibitor was added to motor antifreeze, and waste antifreeze was disposed of by a contractor. After the early 1960s, the antifreeze, which was believed to be free of chromates, was typically discharged to the ground and into storm drains. According to the 1997 RFACS, chromates were detected in Seal Creek in 1978 (PRC 1997). The sump at SWMU 18 evidently drained to the storm drain system, which in turn drained to Seal Creek. SWMU 18 was the suspected source of the chromates detected in Seal Creek. The source of this information is not referenced in the DTSC RFA report (DTSC 1992), however, and additional information on the location of samples and concentrations detected has not been identified. The type was changed when it was discovered that the new antifreeze contained zinc chromate, and biodegradable rust and scale inhibitor was added.

Aerial photographs show that a turntable for locomotives approximately 44 feet in diameter existed 100 feet east of Building IA-51 until at least 1969. A semicircular crack in the asphalt indicates where the turntable was located. The turntable is not present in the 1976 aerial photograph. Although the exact nature of activities in the vicinity of the former turntable is not evident from the aerial photograph, base personnel who work at Building IA-51 say that an incinerator used to destroy classified documents was present in the excavation for the former turntable in 1976. A drop pit (another sump) to collect steam-cleaning water was formerly located 10 feet north of the turntable. The drop pit was destroyed when the turntable was demolished.

2.3.2.5 SWMUs 1 and 16

The area of Building IA-6 was designated SWMU 1 during the RFA (DTSC 1992). Building IA-6 was constructed in the 1940s and housed three steam boilers: two powered by natural gas, and one powered by diesel fuel oil. USTs located south of Building IA-6 were removed in 1989, and Building IA-6 was demolished in the late 1990s. Six groundwater-monitoring wells, MW-1 through MW-6, were installed at SWMU 1 (Figure 4) when the USTs were removed. In April 1998, Reidel Environmental Services (Reidel) of Richmond, California, installed well MW-1 immediately west (downgradient) of the former USTs. In July 1989, Reidel installed wells MW-2 and MW-3 west and south of the former USTs. In September 1990, PRC of San Francisco, California, installed well MW-4, and in September 1993, Furgo West Inc. of Ventura, California, installed wells MW-5 and MW-6 (Cal, Inc. 1996). The monitoring wells were installed to evaluate the lateral and vertical extent of petroleum hydrocarbons in groundwater. MW-2, MW-3, and MW-6 are accessible at the present time. NWSSBD Concord hired Cal, Inc., to excavate contaminated soil surrounding the former USTs, and well MW-1 was abandoned as a result of the excavation. Wells MW-4 and MW-5 have been filled with unknown materials and are unusable.

SWMU 16, which is located near Building IA-46, consists of a public works maintenance storage building and a storage shed where pesticides were mixed for application. Pesticides were detected in soil at the former pesticide storage building at concentrations considered to pose a potential threat to human health (PRC 1997). As a result, the Navy conducted an interim RCRA corrective action at the area that consisted of excavating pesticide-contaminated soil and disposing of the soil off site at a permitted landfill. Confirmation soil samples were collected from the base of the excavation and at the perimeter. A closure report was prepared (CH2M Hill 1997), and the area was recommended for no further action (PRC 1997).

2.3.3 Areas Upgradient from SWMUs 2, 5, 7, and 18

Buildings located hydraulically upgradient (east) from the site were assessed to evaluate their potential contribution to groundwater contamination. The information summarized below was gathered from the draft environmental baseline survey (CDM Federal Programs Corporation 2003).

- Buildings 185, 186, and 398: These buildings consist of a former Marine barracks and dining hall. An oil-water separator was present in one of these buildings.
- Building 252: This building is a former Navy exchange storehouse.
- Building 395: This building was an administration building. A 3,000-gallon UST was removed in 1997. The Contra Costa County Health Services Department (CCCHSD) granted case closure for this UST.
- Building IA-10: This building is a former Marine barracks, later converted to an administration building. A 2,100-gallon UST was removed in 1997.
- Building IA-18 (includes wings IA-18A through IA-18D): IA-18A is a former office building. IA-18B is a former clinic and included a permitted photochemical treatment facility. A closure report for the treatment facility was submitted to DTSC in March 2002. IA-18C is a former administration building. IA-18D is a former industrial relations office building. A 110-gallon diesel UST was removed from Building IA-18 in 1990. CCCHSD granted case closure for the UST in 1994 and was confirmed by the Water Board on September 5, 2000. Fire log entries indicate several incidents of personal vehicles that leaked gasoline in the parking lot of the building in the 1960s.
- Building IA-49: This building was used to store pesticides and asbestos-containing materials and to dispose of fluorescent lights. A RCRA corrective action was completed at the site in 1996 to excavate soil affected with pesticides (CH2M Hill 1997).
- Building IA-52: This building was a gymnasium.
- Building 193: This building was an Auto Hobby Shop at least 200 to 300 feet east of Building IA-52. Potential contaminants include petroleum hydrocarbons and solvents.

2.4 PREVIOUS INVESTIGATIONS

DTSC conducted an RFA at NWSSBD Concord in June 1992 to evaluate the potential for release of hazardous substances from 49 SWMUs (DTSC 1992). In 1996, the Navy completed an RFACS to further evaluate the findings from the DTSC RFA. The RFACS included collection of soil, surface water, groundwater, and septic tank samples; laboratory analysis of the samples; and evaluation of the analytical results. Recommendations from the RFACS included the transfer of TPH-contaminated sites to the Navy's UST program, designed to address the petroleum hydrocarbon contamination. Sites where low levels of VOCs had been detected were recommended for evaluation under the CERCLA IRP (PRC 1997). The primary focus of the RI was to assess the nature and extent of VOCs in groundwater and to provide supplemental data on the nature and extent of TPH-contaminated soil and groundwater at the site (Tetra Tech 2004). The following discussion of the RFACS and CERCLA site investigations focuses on these constituents.

2.4.1 Resource Conservation and Recovery Act Facility Assessment Confirmation Study

The Navy conducted the RFACS in 1996 to further evaluate the findings from the RFA. The RFACS consisted of installation of 53 soil borings within SWMUs 1, 2, 5, 7, and 18; collection of nine grab groundwater samples; and collection of groundwater samples from existing monitoring wells MW-1 through MW-6.

The following subsections present the results of the investigation of TPH and VOCs conducted as part of the RFACS for SWMUs 1, 2, 5, 7, and 18. The last subsection describes work at SWMU 16 associated with an interim RCRA corrective action to remove pesticide-contaminated soil. Unless otherwise indicated, all information in the following subsections was obtained from the RFACS report (PRC 1997).

2.4.1.1 SWMU 1

SWMU 1 was investigated as part of the RFACS to evaluate the potential impact of hydrocarbons associated with a former UST, purge water holding tank, grease and sand trap, and former diesel fuel spill. VOCs were included in the investigation based on the results of previous analytical data for groundwater. TPH-d and TPH-mo were detected in soil samples near the former UST. TPH-d and TPH-mo were also detected in groundwater samples from wells MW-1 and MW-5, downgradient from the former UST.

Tetrachloroethene (PCE) was the only VOC detected in the groundwater samples collected from monitoring wells MW-1 through MW-6. The concentrations of PCE were consistently detected at low estimated ("J"-qualified) concentrations of 5 to 6 micrograms per liter (µg/L). Although the concentrations are considered low, they are equal to or greater than the state and federal MCL for PCE of 5.0 µg/L. Based on the presence of PCE at these low levels in all wells located in SWMU 1 (including the upgradient well MW-2) during the 1996 sampling event, it was concluded that the source of the PCE was upgradient from SWMU 1. SWMU 1 was subsequently transferred to the Navy's UST program.

2.4.1.2 SWMU 2

The RFACS for SWMU 2 included investigation of soil and groundwater near the alleged former burn area and along the drainage path to Seal Creek to evaluate the potential release of hazardous constituents caused by former fire-fighting practices and potential spills of hazardous materials from the hazardous materials storage area.

The maximum concentration of TPH detected in soil at SWMU 2 was 3,400 mg/kg as TPH-mo, and the maximum concentration of TPH detected in grab groundwater samples was 130 micrograms per kilogram. Although TPH was detected in soil and grab groundwater samples collected at SWMU 2, TPH was not detected at concentrations that could threaten human health or the environment. No known USTs or aboveground storage tanks (AST) are associated with SWMU 2, and the previous alleged burn pit at SWMU 2 did not release TPH to soil at concentrations that would require remediation. VOCs were not detected in either soil or groundwater samples collected from SWMU 2.

2.4.1.3 SWMU 5

The RFACS for SWMU 5 investigated soil in the vicinity of Buildings IA-12, and 269 to evaluate potential releases of hazardous constituents at five areas where hazardous wastes (primarily paints) were stored or surface staining was observed.

The soil sampling results indicate low concentrations of 1,1,1-trichloroethane (TCA) (estimated at 0.003 mg/kg) in the vicinity of Building IA-12. Oil and TPH-g at concentrations that did not exceed 100 mg/kg were detected in several samples collected from borings adjacent to a grease and sand trap northwest of Building IA-12 and near the edge of an oil-water separator north of Building IA-43 at the steam-cleaning facility (Building 269). Based on the soil sampling results, the RFACS concluded that significant organic or inorganic contamination was not present in soil at SWMU 5.

VOCs were detected at very low concentrations in grab groundwater samples collected at SWMU 5. Detected VOCs included 1,1,1-TCA; trichloroethene (TCE); 1,1-dichloroethane (DCA); and 1,2-dichloroethene (DCE). The source of the VOCs in groundwater was not identified, but may be attributable to minor surface spills and storage of solvents at the locomotive maintenance area (Building IA-12) and the steam-cleaning area. SWMU 5 was recommended for further investigation under the CERCLA IRP, together with SWMUs 2, 7, and 18, to establish the location of any potential sources of VOCs and to evaluate whether contaminants were migrating through soil.

2.4.1.4 SWMU 7

The RFACS for SWMU 7 investigated an area east of Building IA-15 to evaluate potential releases of hazardous constituents at areas where hazardous wastes were stored and where surface staining was observed. Soil samples from six borings were analyzed for VOCs, and none were detected.

Soil borings were also completed near the four former 11,500-gallon USTs and north of the former USTs. TPH-d was detected in several soil samples; however, the contaminated soil was excavated and disposed of off site during removal of the USTs (Niccum 1999).

Groundwater samples collected in 1995 throughout SWMU 7 contained petroleum hydrocarbons. Two groundwater samples collected immediately east and west of the former USTs contained 130,000 and 25,000 µg/L of TPH-d. One groundwater sample collected east of the former USTs contained 2 µg/L of 1,2-DCA. No other VOCs were detected in any of the groundwater samples.

SWMU 7 was transferred to the Navy's UST program so that TPH contamination in soil could be addressed because of the presence of USTs and petroleum hydrocarbons in soil.

2.4.1.5 SWMU 18

The investigation of soil and groundwater for the RFACS for SWMU 18 included evaluation of nine soil boring and two grab groundwater samples. The objective of soil sampling at SWMU 18 was to investigate the presence of hydrocarbons in the vicinity of the oil sump, vehicle maintenance area, locomotive steam cleaning area, and railroad turntable, and to evaluate the storm drainage outfall for residual contamination from surface discharges in the area.

One soil boring was advanced to 15.5 feet below ground surface (bgs) adjacent to the former sump east of Building IA-51, and another was advanced near the former turntable. Soil samples from both borings were analyzed for TPH-d and TPH-mo. Soil samples from the boring near the former locomotive turntable were also analyzed for VOCs. Neither soil boring contained detectable concentrations of TPH-d or VOCs. TPH-mo was detected at a concentration of 1,100 mg/kg near the locomotive turntable in a sample collected at a depth of 5 feet bgs. Eight step-out soil borings were installed surrounding the turntable and sampled for analysis of TPH-mo. Soil samples from four of the eight borings contained TPH-mo at concentrations ranging from 340 to 9,700 mg/kg at depths of 1.5 to 2.5 feet bgs.

TPH-mo was also detected in two grab groundwater samples collected from the original two borings at a concentration of 740 µg/L near the sump and at a concentration of 540 µg/L near the turntable. The RFACS recommended an investigation of groundwater to evaluate the TPH detected in groundwater at SWMU 18.

2.4.1.6 SWMU 16

An interim RCRA corrective action was conducted at SWMU 16 in 1996 to remove pesticide-contaminated soil. The results for the confirmation samples in the area are included in the RFACS report (PRC 1997). SWMU 16 was used to store paints, solvents, thinners, and boiler chemicals. SWMU 16 also includes an area where florescent light bulb tubes were crushed, so the area was investigated for potential mercury contamination. The former hazardous waste storage area at SWMU 16 also stored asbestos-containing materials. The area was therefore also sampled for analysis of asbestos during the RFACS. Based on the soil removal and lack of contamination by mercury and asbestos, SWMU 16 was recommended for no further action.

2.4.2 Comprehensive Environmental Response, Compensation, and Liability Act Investigations

After the RFACS, the Navy conducted follow-up CERCLA investigations at SWMUs 2, 5, 7, and 18 to confirm the presence, levels, and potential sources of contaminants to soil and groundwater as well as to evaluate the need for additional RI and abatement activities. In January 1999, six groundwater-monitoring wells were installed at SWMUs 1, 2, 5, 7, and 18 to evaluate potential sources of VOCs in groundwater in this area. These wells are MW-07, MW-08, MW-09, MW-10, MW-11, and MW-12. Figure 4 shows the locations of these wells. Additionally, one upgradient monitoring well (MW-13) and one downgradient monitoring well (MW-14) were installed to delineate the extent of VOCs in groundwater. The locations for the monitoring wells were selected to close data gaps, verify the results of groundwater sampling during the RFACS, and identify potential sources. After the monitoring wells had been installed, four quarters of groundwater sampling were conducted (Tetra Tech 2001a).

Samples from well MW-10 in SWMU 5 contained the highest concentrations of VOCs detected during the four quarters of sampling in 1999. PCE was detected in all four quarterly groundwater samples collected from well MW-10 at concentrations ranging from 62 to 72 µg/L. TCE was also detected in all four quarterly groundwater samples collected from well MW-10 at concentrations ranging from 19 to 22 µg/L. Detectable concentrations of cis-1,2-DCE and were reported for the second quarter sampling event (April 1999) at 4 µg/L (cis-1,2-DCE) and 2 µg/L (trans-1,2-DCE) (Tetra Tech 2001a).

PCE was also detected during all four quarters of groundwater sampling in samples collected from wells MW-11 and MW-14 at estimated concentrations between 2 and 7 µg/L. TCE was detected during all four quarters of sampling in samples collected from monitoring wells MW-8 and MW-12 at estimated concentrations between 1 µg/L and 2 µg/L. TCE was also detected during the second (April 1999) and third quarters (July 1999) of groundwater sampling in samples collected from monitoring wells MW-9 at an estimated concentration of 0.6 µg/L for both quarters. VOCs were not detected in any of the soil samples collected when the monitoring wells were installed (Tetra Tech 2001a).

2.5 REGIONAL GEOLOGY AND HYDROGEOLOGY

This section presents an overview of the regional geologic and hydrogeologic conditions as well as the groundwater basin plan and drinking water supply at NWSSBD Concord.

2.5.1 Regional Geology

NWSSBD Concord is located in the Sacramento-San Joaquin Delta area of the great Valley Geologic Province. The regional geologic features include several northwest-trending fault systems that divide Contra Costa County into large tectonic blocks. Broad lowlands are underlain by thick, unconsolidated, Pleistocene-aged alluvial sediments eroded from upthrown blocks. The major Concord and Clayton Faults are known to exist in the vicinity of NWSSBD Concord. The Concord Fault passes 2 miles south of NWSSBD Concord and is classified as an active, right-lateral, strike-slip fault. The Clayton Fault lies at the base of Los Medanos Hills as it passes through NWSSBD Concord. The Clayton Fault is classified as active or potentially active (PRC 1997).

The surficial geology of the Inland Area consists of two alluvial areas. The first area comprises alluvial deposits derived from erosion of the geologic units of Los Medanos Hills. The second consists of alluvial deposits associated with the low and gently sloping hills to the southwest. The Seal Creek drainage area separates these two geologic areas (PRC 1997). The site is located on the northeast side of Seal Creek in the Inland Area.

Alluvium in the Inland Area consists of beds of sandy, silty, and clayey soils. Silty soils appear to predominate. An approximately 3-foot-thick layer of dark brown or gray, clayey soil generally overlies the alluvium throughout the region (PRC 1997).

2.5.2 Regional Hydrology

The Diablo Range intercoastal highlands include both smooth, rolling hills and relatively rugged mountains, ranging in elevation from 100 feet above mean seal level (msl) along the San Francisco Bay to 3,849 feet above msl at Mount Diablo. The intermountain valleys and San Francisco Bay consist of flood plains and low terraces, with gently rolling fans and old terrace remnants adjacent to the uplands. NWSSBD Concord lies about 10 miles west of the confluence of the Sacramento and San Joaquin Rivers. This confluence forms the Delta region, which contains more than 600 miles of interconnected and meandering tidal waterways. Drainage from NWSSBD Concord is exclusively into Suisun Bay.

Locally, NWSSBD Concord lies within the Mount Diablo/Seal Creek Watershed, which drains an area of about 36 square miles. This watershed is bounded to the south by the northern peak of Mount Diablo and to the north by Suisun Bay. Streams that drain the watershed have their headwaters on the slopes of Mount Diablo and flow through Mount Diablo Creek through Clayton Valley and NWSSBD Concord to Hastings Slough in the tidal waters of Suisun Bay. Mount Diablo Creek becomes Seal Creek after it enters NWSSBD Concord (PRC 1997). Suisun Bay is 4 miles downstream from the site.

The Navy formerly owned and operated three wells along Kinne Boulevard. These wells were drilled in 1928 and were used until the 1960s, when they were abandoned but not closed. The wells were eventually closed in accordance with the well closure requirements of CCHSD’s Environmental Health Division (PRC 1995).

The Contra Costa County Water District operates a number of drinking water supply wells that surround Mallard Reservoir. These wells augment aqueduct supplies of drinking water to Mallard Reservoir during droughts (DTSC 1992).

One irrigation water supply well is located within the Diablo Creek Golf Course next to the site. According to Rod Kilcoyne of the Diablo Creek Golf Course, the irrigation well operates every day in the summer and constitutes the sole source of irrigation for the golf course. An estimated 750,000 gallons per day of water is pumped from the well during the hottest days of summer. The well operates 24 hours per day to keep up with that demand. The well was constructed in March 1977 and was originally drilled to a depth of 350 feet bgs. The well is fitted with a 20-inch-diameter steel casing to a depth of 260 feet bgs. The well casing is perforated at 70 to 85, 100 to 155, 165 to 200, and 225 to 250 feet bgs. The well pumps to a holding lake, where irrigation water is extracted by pumps. The well is not used for drinking water. The pro shop at the golf course is connected to water supplied by the Contra Costa County Water District (Kilcoyne 2003).

A well known as the Conco well is located across Port Chicago Highway from the golf course. Another water supply well located adjacent to NWSSBD Concord property formerly served the Town of Clyde. The well is reportedly no longer in use, and the Navy is unaware of the closure status of the well. Additional wells may be located in the industrial area west of the site and in the Town of Clyde. Locations and details of other wells are unknown to the Navy.

2.5.3 Groundwater Basin Plan and Drinking Water Supply

NWSSBD Concord is located within the Clayton Groundwater Basin, as identified in the water quality control plan for the San Francisco Bay region (Water Board 1995) and associated amendments (Water Board 2000). This plan, referred to as the "basin plan," identifies the Clayton Basin as a potentially significant groundwater basin in the San Francisco Bay Region. In the basin plan, the term "groundwater" is defined to include all subsurface waters, whether they meet the definition of an aquifer or occur within identified groundwater basins. Unless specifically exempted, a groundwater basin or portion of is designated as potentially suitable for municipal and domestic water supply (Water Board 2000).

Groundwater in the area meets the federal definition of a potential drinking water supply (Class II groundwater [EPA 1986]) based on several factors. The first of these factors is the presence of one or more operating drinking water wells within 2 miles of the site (known as the Classification Review Area). The second factor is that the concentrations of total dissolved solids (TDS) in the groundwater are significantly lower than EPA's 10,000-milligram-per-liter (mg/L) threshold. Third, although well yield has not been measured at the site itself, it likely exceeds the EPA minimum threshold of 150 gallons per day. Because the groundwater meets these conditions, it is considered Class II groundwater according to the EPA criteria.

2.6 Results of Site-Specific Physical Characterization

The following subsections discuss the site geology and groundwater flow and hydraulic gradients at the site based on the results of the site-specific physical characterization.

2.6.1 Site Geology

Each soil boring installed at the site was logged in accordance with the Unified Soil Classification System (USCS) to provide adequate and consistent descriptions of soil encountered. The soil borings were advanced to just below the groundwater table, and depths ranged from 16 feet bgs in boring SB011 to 58 feet bgs in SB030. The depth of the groundwater at the time the borings were drilled is indicated on the lithologic logs. Groundwater samples were collected at least 1 foot below the depth of the groundwater indicated on the water quality data sheets. Up to 3 feet of fill material was encountered in some borings. The fill material encountered consisted of a heterogeneous mixture of sand, silt, clay, and gravel, with sparse organic debris.

Soils in the north-central portion of NWSSBD Concord consist largely of clay-rich alluvium derived from the nearby hills. Intercalated layers of well-sorted (poorly graded), silty sands to pebbly alluvium were encountered in the vicinity of Seal Creek and are most likely derived from upstream areas. Soils in the central and western portions of the site toward Seal Creek tend to be coarser at shallower depths but are graded comparatively finer than soils in the north-central area. Soil consistency became stiff to very stiff with depth in both areas, and in some cases, auger refusal was encountered. These lithologic conditions are consistent with the regional geology.

Three hydrogeologic cross sections were developed using available data to illustrate subsurface conditions at the site. Figure 5 depicts the locations of these three cross sections, and Figures 6 through 8 show cross sections A-A', B-B', and C-C'. Cross section A-A' is oriented east to west to correspond approximately to the predominant direction of groundwater flow, and cross sections B-B' and C-C' illustrate cross-gradient hydrogeologic conditions. As the cross sections show, the upper 5 to 10 feet of site materials generally consists of finer materials such as clays and silts that grade to coarser sandy silts and sands with depth in the central and eastern portions of the site. As described in the boring logs, the uppermost native soils consist of inorganic clays of low to medium plasticity that grade to sandy and silty clays with depth. Interbedded lenses of coarser, sandier materials occur with depth and are 1 foot to several feet thick. Coarser, sandier material becomes less evident toward the northwest. Zones of black clayey material were encountered in several borings, indicating the presence of organic material deposited during sedimentation. In general, soil color ranged from black to brown and tan, depending on the amount of organic material in the soils and on the geochemical environment.

2.6.2 Groundwater Flow and Hydraulic Gradients

Based on groundwater levels collected in monitoring wells at the site, the groundwater elevation ranges from approximately 45 feet above msl in the eastern part of the site to approximately 37 feet above msl in the western part of the site. Figure 9 shows the potentiometric surface contours generated from the groundwater level data collected on March 5, 2002. Water level elevations for the monitoring wells are based on the 1929 National Geodetic Vertical Datum. As indicated on Figure 10, groundwater generally flows westward under an average hydraulic gradient of 0.005 foot per foot. The water level measurement from monitoring well MW-13 was not used to generate the potentiometric surface map because the water level in this well most likely represents a different water-bearing zone that should not be compared with the water table aquifer.

2.6.3 Aquifer Slug Testing Results

Aquifer slug testing was conducted at monitoring wells MW-2, MW-7, MW-8, MW-9, MW-10, MW-11, and MW-13 to obtain estimates of the hydraulic conductivity of the materials beneath the site. Table 1 summarizes the results of the slug test, including the monitoring well construction details and the lithology of the screened intervals, estimated values of hydraulic conductivity for those lithologies, test details, and test results. As discussed in Section 2.6.1, the geology beneath the site consists of silty, sandy, and clayey alluvial materials. Monitoring wells MW-8, MW-9, MW-10, and MW-13 are screened in sandy materials that contain varying amounts of silt and clay. Monitoring wells MW-7 and MW-11 are screened in clays and silts.

The estimated hydraulic conductivity values were calculated using AQTESOLV (HydroSOLV, Inc. 1998), an aquifer testing data analysis software package. The estimated values from all valid slug test data from wells MW-2, MW-8, MW-9, MW10, and MW-13 range from approximately 1 to 9 feet per day for both test methods. The slug test results from monitoring wells MW-7 and MW-11 were not valid because the water level recovery curves for these tests suggest that the entire tests represented only filter pack dewatering. The results from the Hvorslev tests are consistently higher than those obtained using the Bouwer and Rice test. Omitting the skewed results from wells MW-7 and MW-11, the geometric mean hydraulic conductivity from all other tests is 3 feet per day as calculated from the Bouwer and Rice test and 4 feet per day as calculated from the Hvorslev test. All geometric mean values for hydraulic conductivity fall within the expected range of published values for these materials (0.0001 to 1 foot per day for clayey or silty materials and 0.001 to 50 feet per day for sandier materials (Fetter 1988).

Groundwater flow velocities were estimated using the unskewed geometric mean hydraulic conductivity values of 3 and 4 feet per day, the calculated hydraulic gradient for the site of 0.005 foot per foot, and an assumed effective porosity range of 0.15 to 0.25 (the representative range for clays and silts up to sands). Based on these values, the calculated groundwater velocities at the site range from approximately 22 to 49 feet per year.

2.7 CURRENT LAND USE AND FUTURE LAND REUSE

Land in the vicinity of NWSSBD Concord is used for a mixture of industrial, residential, agricultural, and open space purposes. Los Medanos Hills separate the Tidal and Inland Areas of the facility. A portion of the intervening land is privately owned and is leased to the Pacific Gas and Electric Company for storing natural gas by deep-well gas injection. The land is also used for cattle grazing.

NWSSBD Concord is bordered on the south by residential sections of the City of Concord. These neighborhoods are made up of single-family, medium-density housing. Most of the housing dates from the mid-1950s. In addition, seven public schools and several parks are adjacent to the Navy property line.

The Diablo Creek Golf Course occupies a 162-acre triangle of land between State Route 4, the Port Chicago Highway, and the Inland Area of NWSSBD Concord. The City of Concord operates a large water treatment plant and the Mallard Reservoir just west of the Port Chicago Highway.

Land use near NWSSBD Concord is diverse and includes industrial and residential properties, range land, and open space. Residential development is located in the Town of Clyde west and slightly north of SWMUs 2, 5, 7, and 18. Residential areas of the City of Concord located closest to SWMUs 2, 5, 7, and 18 are south of State Route 4. Railroad land holdings and utility easements cross through the Inland Area. Los Medanos Hills separate the Tidal and Inland Areas of NWSSBD Concord. Los Medanos Hills are privately owned and are leased to Pacific Gas and Electric Company and to local ranchers for cattle grazing. Land north of State Route 4 and west of NWSSBD Concord is zoned for industrial development. The City of Concord operates the Diablo Creek Golf Course west of SWMUs 2, 5, 7, and 18.

There are currently no plans for modification of the existing land use at NWSSBD Concord. The facility will remain as a military installation into the foreseeable future.

3.0 RESULTS OF REMEDIAL INVESTIGATION

The following subsections discuss the analytical results from the RI at SWMUs 2, 5, 7, and 18 (Tetra Tech 2004). The RI included soil and groundwater sampling conducted in February and March 2002 and soil gas sampling conducted in January and April 2004. The depths for soil sampling ranged from 2 to 14 feet bgs. Soil and groundwater samples were analyzed for one or more of the following: TPH extractables and purgeables (EPA Method 8015), VOCs (EPA Method 8260B), and natural attenuation parameters, including metals (EPA Methods 300.0 and 200.7).

Analytical results for soil and groundwater are summarized in Sections 3.1 and 3.2, analytical results for VOCs in soil gas are summarized in Section 3.3, and groundwater natural attenuation parameters are summarized in Section 3.2.2. Concentrations of compounds detected below the laboratory method reporting limit are considered estimated and are distinguished in tables and figures with a “J” after the value.

Section 6.0 discusses the application of these results to human health in the qualitative HHRA.

3.1 RESULTS FOR SOIL SAMPLES

Soil samples collected at the site have been analyzed for VOCs, SVOCs, metals, pesticides, polychlorinated biphenyls, petroleum hydrocarbons, and total organic carbon. These results are presented in the RI report (Tetra Tech 2004). A total of 158 soil samples collected from 39 different locations were analyzed for VOCs. VOCs were reported in two of the 158 soil samples. Table 2 presents a statistical summary of VOC and TPH compounds detected in soil samples at the site. Soil samples were also collected and analyzed for TPH during the RI. Results for TPH are discussed in the RI report (Tetra Tech 2004).

TCE and PCE were detected at estimated concentrations of 0.002 mg/kg (TCE) and 0.001 mg/kg (PCE) in the sample collected from 28 feet bgs from soil boring SB018. SB018 is located at the western end of the locomotive steam-cleaning area Building 269. TCE was detected at an estimated concentration of 0.0006 mg/kg in the sample collected from 6 feet bgs from soil boring SB024. SB024 is located near the southwestern corner of Building IA-12. The concentrations reported for these samples are near the laboratory method detection limits and are therefore considered estimated. VOCs were not detected above screening level criteria in any of the soil samples collected from the site. Based on the results of the investigation of soil and the RFACS conducted in 1996 (Section 2.4.1), VOCs have not significantly contaminated soil at the site. Figure 11 presents VOC results for soil sampling locations.

3.2 RESULTS FOR GROUNDWATER SAMPLES

Groundwater samples were collected from 14 existing groundwater monitoring wells and 32 grab groundwater sampling locations. A total of 48 samples were collected and analyzed for VOCs, and 21 groundwater samples were collected and analyzed for TPH constituents. Samples for analysis of TPH and VOCs were collected from near potential source areas. Samples collected from a larger area also were analyzed for VOCs in accordance with the work plan because of the propensity for VOCs to exhibit increased mobility and persistence in groundwater when compared with TPH constituents. MWIA-17 was the only monitoring well selected for TPH analysis; all other results for TPH in groundwater are from the grab groundwater samples.

Table 3 presents a statistical summary of all detected compounds in the groundwater samples. Figures 12 through 14 present groundwater sampling locations and results for samples with detectable concentrations of VOCs. Figure 15 presents results for TPH detected in groundwater samples. The distribution of TPH is discussed in more detail in the RI report (Tetra Tech 2004). Results for VOCs in groundwater and natural attenuation parameters for groundwater are discussed in Sections 3.2.1 and 3.2.2.

3.2.1 Volatile Organic Compounds in Groundwater

Figures 13 and 14 are simplified presentations of the analytical data depicting sampling locations and ranges of concentrations for PCE and TCE. PCE, TCE, and cis- and trans-1,2-DCE were detected in samples collected from 10 monitoring wells and from 21 grab groundwater sampling locations in February and March 2002. PCE and TCE were generally detected at relatively higher concentrations than cis- and trans-1,2-DCE.

The sample collected from well MW-10 downgradient of the locomotive steam-cleaning facility contained the highest concentration of PCE detected at the site (100 µg/L). The grab groundwater sample from boring SB024 downgradient of the former waste oil tank at Building IA-12 contained the second-highest concentration of PCE, of 86 µg/L. PCE was generally detected in groundwater at concentrations between 30 and 50 µg/L at locations in the immediate area of the highest detections downgradient from well MW-10 and boring SB024. Relatively low concentrations of PCE were detected in samples collected from sampling locations in SMWU 2 south of Kinne Boulevard (Figure 13). PCE was not detected in samples collected from locations upgradient of SWMU 5.

Based on Figures 12 and 13, concentrations of PCE attenuate with distance from well MW-10 and boring SB024. Boring SB009 is located about 50 feet downgradient from well MW-10. The concentration of PCE in the sample collected from boring SB009 was 43 µg/L, down from 100 µg/L in the sample collected at well MW-10. Boring SB004 is 300 feet downgradient from well MW-10. At that location, the groundwater sample contained 33 µg/L of PCE. The groundwater sample from well MW-2, approximately 600 feet downgradient from well MW-10, contained 5 µg/L PCE. The monitoring well farthest west is MW-14, located approximately 1,100 feet from MW-10; the groundwater sample from MW-14 contained 3 µg/L. Although PCE was detected in samples from the groundwater monitoring wells, it was not detected in the Diablo Creek Golf Course irrigation supply well located west of well MW-10.

The concentrations of PCE presented in Figure 12 were divided into four general categories, as presented in the table below, for evaluation.

PCE Concentration Range	Number of Samples
Not Detected	22
Less Than 5 µg/L	11
5 µg/L to 10 µg/L	6
10 µg/L and above	6

Notes:
µg/L Micrograms per liter
PCE Tetrachloroethene

Many of the nondetected concentrations are located in upgradient and cross-gradient areas. Results indicate that upgradient sources are not present. Results for PCE in all samples collected from the boundaries of the investigation were either nondetected or were less than 5 µg/L.

The distribution of TCE was similar to that of PCE within SWMU 5 (Figures 12 and 14), except the detected concentrations of TCE were generally lower than the concentrations of PCE. The groundwater sample from soil boring SB024 contained the maximum TCE concentration, of 38 µg/L. Boring SB024 is located near the west corner of and downgradient from Building IA-12. Boring SB024 is the same location where the second-highest concentration of PCE was detected. The sample from monitoring well MW-10, downgradient from Building 269, contained the second-highest concentration of TCE, of 29 µg/L. Well MW-10 is the location where the highest concentration of PCE was detected in groundwater. TCE was not detected in samples collected from locations in SMWU 2 but was detected at low or estimated concentrations of 0.9 to 2 µg/L from samples collected from locations upgradient of SWMU 5.

The concentrations of TCE presented in Figure 14 were divided into four general categories, as presented in the table below, for evaluation.

TCE Concentration Range	Number of Samples
Not Detected	22
Less Than 5 µg/L	17
5 µg/L to 10 µg/L	0
10 µg/L and above	6

Notes:
µg/L Micrograms per liter
TCE Trichloroethene

Cis-1,2-DCE was detected in samples collected from nine locations at an estimated concentration of 0.8 µg/L to the maximum quantifiable concentration of 7 µg/L. Cis-1,2-DCE was detected only in samples collected from locations within SWMUs 5 and 7 and from downgradient sampling location SB004. Trans-1,2-DCE was detected in samples collected from seven sampling locations at an estimated concentration of 0.9 µg/L to the quantifiable concentration of 4 µg/L. Trans-1,2-DCE was also detected only in samples collected from locations within SWMUs 5 and 7 and from downgradient sampling location SB004.

The detected concentrations of VOCs discussed above are from samples collected in SWMU 5 and 7 near Building 269, the locomotive cleaning area. These samples were also collected downgradient of a former waste oil UST, which is located upgradient and on the southern side of Building IA-12.

3.2.2 Natural Attenuation Parameters for Groundwater

Groundwater samples from existing monitoring wells and selected grab groundwater samples were collected for laboratory and field analysis for natural attenuation parameters. Groundwater samples were collected from six existing monitoring wells and three soil boring locations for analysis of alkalinity, chemical oxygen demand (COD), TDS, hardness, chloride, methane, nitrate, nitrite, and sulfate. Parameters measured in the field included dissolved oxygen (DO), dissolved ferrous iron, hydrogen sulfide, pH, and oxygen reduction potential (ORP). Figure 16 presents analytical results for inorganic and natural attenuation parameters in groundwater. Data on natural attenuation are presented in more detail in the RI report (Tetra Tech 2004).

Biodegradation can occur by several processes under both aerobic and anaerobic conditions. The two common biodegradation pathways are (1) mineralization, where an organic compound is directly used as a growth substrate (food source) and is broken down to inorganic molecules, such as carbon dioxide, water, and, if chlorinated, chlorine; and (2) co-metabolism, where a compound is consumed and converted incidentally during microbial consumption of other compounds.

Petroleum hydrocarbons can serve as substrates for microbial growth and are therefore commonly biodegraded through direct mineralization. On the other hand, only specific chlorinated solvents (for example, vinyl chloride, dichloromethane, and chloroethane) can be directly mineralized. Instead, most chlorinated solvents are co-metabolically biodegraded. Chlorinated solvents are co-metabolized in aerobic environments (in the presence of oxygen) by nonspecific microbial oxygenase enzymes produced by microorganisms to metabolize other growth substrates (for example, methane, propane, toluene, ammonia, ethene, and ethane). In anaerobic environments, chlorinated solvents act as electron acceptors in a process called reductive dechlorination, where hydrogen atoms replace chlorine atoms on the chlorinated solvent molecule. Other carbon substrates (for example, hydrocarbons) serve as electron donors in these reactions (Remediation Technologies Development Forum [RTDF] 1996).

Data suggest that aerobic conditions are present at the site. DO was detected in all groundwater samples at concentrations generally exceeding 3 mg/L and as high as 8 mg/L. The positive ORP readings, nondetectable methane gas, substantial concentrations of sulfate, and the absence of dissolved iron indicate oxidizing conditions for all but three samples. Lower ORP readings from grab groundwater samples collected from borings SB030, SB031, and SB032 are not consistent with results for either DO or dissolved iron. Samples collected from monitoring wells are considered more representative of ambient conditions than those collected from soil borings. Furthermore, borings SB030, SB031, and SB032 are located at relatively higher elevations upgradient from the SWMUs.

The following is a summary of natural attenuation processes that are likely occurring at the site. First, the preponderance of data on attenuation parameters indicate an aerobic environment in the area of the site. Reductive dechlorination, which is the primary degradation pathway for PCE and TCE, is unlikely to occur under aerobic conditions. Therefore, the most significant natural attenuation mechanisms for these compounds are likely to be advection, dispersion, and sorption.

The microorganisms that mediate the biodegradation reactions described above are generally thought to be ubiquitous in subsurface environments. Because site conditions and interactions between different groups of microorganisms participating in biodegradation reactions will differ from site to site, patterns and completeness of intrinsic biodegradation will also differ from site to site (RTDF 1996). The kinetics of the biodegradation process and long-term trends in concentration are difficult to predict on the basis of the limited sampling conducted.

3.3 RESULTS FOR SOIL GAS SAMPLES

As discussed in Section 3.3, soil gas samples were initially collected in January 2004. Based on a review of analytical results for the initial soil gas samples, additional soil gas samples were collected at five step-out locations. Tables 4 and 5 present analytical results for soil gas samples analyzed at the mobile laboratory (Mobile Chem) and the stationary laboratory (AIRTOX). Figure 16 shows the soil gas sampling locations and results. Most soil gas samples were collected from 5 feet bgs; however, one sample was collected from 6.5 feet, and a second soil gas sample was collected from 10 feet bgs at borings SG8, SG10, SG15, SG24, SG29, and SG32.

Of the 34 sampling locations where initial soil gas samples were collected, only four contained VOCs at concentrations that exceed the environmental screening levels (Water Board 2003) for intrusion of soil gas to indoor air under a residential scenario. Each of these samples was collected from near the former waste oil tank. The proximity of the former waste oil tank suggests that leakage from the tank was responsible for the detected VOC contamination. Analytical results for samples from soil gas sampling locations SG18, SG25, SG31, and SG33 exceeded the Water Board screening criteria. The maximum concentration of VOCs was detected at SG31 in a sample from 5 feet bgs. The soil gas sample from that location also contained cis-1,2-DCE at 8,100 micrograms per cubic meter ($\mu g/m^3$); TCE at 19,000 $\mu g/m^3$; and PCE at 120,000 $\mu g/m^3$. The Water Board screening levels for these constituents are 7,300 cis-1,2-DCE; 1,200 TCE; and 410 $\mu g/m^3$ PCE (Water Board 2003). Only three other sampling locations yielded soil gas samples whose results exceeded the Water Board criteria; the maximum detected concentration of cis-1,2-DCE, TCE, and PCE at these locations was about 1 to 2 orders of magnitude lower than the maximum concentration detected in the sample collected from SG31.

The second soil gas sampling event at the five step-out locations was conducted to investigate other potential source areas and to encircle the area of the former waste oil tank. Although VOCs were commonly detected at low concentrations in the step-out samples, none of the sample results exceeded the Water Board screening criteria (Water Board 2003). Analytical results from the field laboratory and the stationary laboratory compare favorably.

Results for the soil gas samples indicate that the former waste oil tank is the likely source of VOC contamination at the site. Soil gas samples collected from upgradient and downgradient of the former waste oil tank did not contain VOCs at concentrations exceeding the Water Board screening criteria.

4.0 RESULTS OF QUALITATIVE HUMAN HEALTH RISK ASSESSMENT

A qualitative HHRA was conducted to assess the potential for exposure to residual chemicals at concentrations that may cause adverse health effects. The goal of the HHRA was to identify chemicals of potential concern (COPCs) that could be present at concentrations associated with adverse health effects. The HHRA considered current and potential future site uses, identified potential human receptors, and identified potentially complete exposure pathways to affected media.

The site is currently used for military purposes and will continue that use into the foreseeable future. Although it is unlikely that the site will be developed in the near future for residential housing, residential screening values were used to evaluate the most conservative unrestricted future land-use scenario.

The following steps were performed to complete the HHRA:

- Evaluate the quality of data for soil, groundwater, and soil gas, and select data that met EPA risk assessment data quality standards (EPA 1989)
- Identify the maximum concentration of each chemical detected in soil, groundwater, and soil gas
- Identify complete exposure pathways
- For COPCs in soil, perform a screening evaluation that compares maximum detected concentrations with residential soil PRGs (EPA 2002a)
- For COPCs in groundwater, perform a screening evaluation that compares maximum detected concentrations with groundwater screening levels for the protection of residential indoor air (Water Board 2003), California Department of Health Services MCLs (California Department of Health Services 2000), and tap water PRGs (EPA 2002)
- For COPCs in soil gas, perform a screening evaluation that compares the maximum detected concentrations to soil gas screening levels for the protection of residential indoor air (Water Board 2003), and further evaluate the potential migration of soil gas contaminants to indoor air using the Johnson and Ettinger vapor transport model and site-specific input parameters and assumptions as necessary.

4.1 EXPOSURE PATHWAYS

EPA and DTSC guidance documents on human health risk assessment were used to identify relevant exposure pathways. The exposure pathways consist of four necessary elements (EPA 1989):

- Source and mechanism of chemical release
- Retention or transport medium (or media in cases involving media transfer)
- Point of potential human contact with the contaminated medium
- Exposure route (for example, ingestion) at the exposure point

A pathway is considered "complete" only if these four conditions are applicable. The potential exposure pathways and routes evaluated include the following:

- Incidental ingestion of soil
- Direct dermal contact with soil
- Inhalation of particulate emissions from soil
- Inhalation of vapors in indoor air (derived from soil gas or groundwater)
- Ingestion of groundwater
- Dermal contact with groundwater

The exposure pathways identified above are considered complete and were evaluated qualitatively for the potentially exposed populations and land-use scenarios identified. The currently known and identified affected media are soil, groundwater, and soil gas. The exposure routes are defined as the physical ways chemicals may enter the human body (for example, through ingestion, inhalation, and dermal absorption).

Groundwater at the site is not currently used as a source of drinking water; therefore, no current pathway exists for human ingestion of groundwater or dermal contact with groundwater. Although groundwater at the site is not currently used as a source of drinking water, data for groundwater were conservatively screened against drinking water criteria following guidance in the basin plan (Water Board 1995) and amendments (Water Board 2000). The basin plan and amendments define all subsurface waters as potential sources for municipal and residential uses.

4.2 SCREENING LEVELS

Screening values were selected that accurately and conservatively represent each complete exposure pathway. Screening levels for soil, groundwater, and soil gas are discussed below.

4.2.1 Screening Levels for Soil

Residential PRGs were used in the RI as the screening criteria for soil (EPA 2002a). Residential PRGs were selected instead of industrial PRGs to evaluate unrestricted land use under the most conservative land use scenario. Table 6 summarizes the maximum concentrations of contaminants detected in soil and the PRGs used for the HHRA.

4.2.2 Screening Levels for Groundwater

Residential groundwater screening levels for protection of indoor air quality (Water Board 2003) were selected for indirect exposure to groundwater contamination. Table 7 summarizes the maximum concentrations of contaminants detected in groundwater and screening levels for indirect exposure to groundwater used for the HHRA. These screening values were developed using the Johnson and Ettinger vapor transport model (Johnson and Ettinger 1991). This model considers both diffusive and convective flow of subsurface vapors into buildings. This model typically overestimates vapor migration and is therefore considered protective of human health. No maximum detected concentration of a contaminant in groundwater exceeded its indirect exposure screening criterion.

The California-promulgated drinking water standards (referred to as MCLs) (California Department of Health Services 2000) and residential tap water PRGs (California Department of Health Services 2000 and EPA 2002a) were used for ingestion of and dermal contact with groundwater. Table 7 summarizes the groundwater MCLs and tap water PRGs used for the HHRA. MCLs are the enforced drinking water standards. Tap water PRGs are human health risk-based goals for domestic water. Domestic water at the site is currently municipally supplied; therefore, there is no current pathway for ingestion of or dermal contact with groundwater.

4.2.3 Screening Levels for Soil Gas

Residential soil gas screening levels for protection of indoor air quality (Water Board 2003) were selected for indirect exposure to contaminants in soil gas. These screening values were developed using the Johnson and Ettinger vapor transport model (Johnson and Ettinger 1991). This model considers both diffusive and convective flow of soil gas vapors into buildings. As is frequently the case with indirect exposure to vapors from groundwater, this model typically overestimates vapor migration from soil gas to indoor air and is therefore considered protective of human health. All concentrations of contaminants detected in soil gas at concentrations that exceed the screening criteria are presented in Figure 16. The soil gas screening levels presented in Tables 4 and 5 are used for the HHRA.

As noted in Tables 4 and 5, cis-1,2-DCE; TCE; and PCE were detected in soil gas samples collected at four locations at maximum concentrations that exceeded residential screening levels for soil gas, as follows:

- SG18 – PCE (1,000 $\mu g/m^3$)
- SG25 – TCE (2,400 $\mu g/m^3$) and PCE (15,000 $\mu g/m^3$)
- SG31 – cis-1,2-DCE (8,100 $\mu g/m^3$); TCE (19,000 $\mu g/m^3$); and PCE (120,000 $\mu g/m^3$)
- SG33 – PCE (730 $\mu g/m^3$)

The Water Board developed the residential soil gas screening levels using the Johnson and Ettinger vapor transport model and assuming that the vadose zone consists of highly permeable sand (Water Board 2003). In fact, the vadose zone at the site consists of silty clay, which is less permeable than sand (see Figure 9 through 11). The maximum detected concentrations of cis-1,2-DCE, TCE, and PCE in soil gas were further evaluated using the Johnson and Ettinger vapor transport model, site-specific input parameters, and the model-specific assumptions summarized below.

- Depth below grade to bottom of enclosed space floor, 15 centimeters (cm). It was assumed that all future construction was slab-on-grade.
- Soil gas sampling depth below grade (LS), 152.4 cm. This is the Johnson and Ettinger model's default assumption. In addition, all but one of the soil gas samples considered in this analysis were collected from this depth. (Note: The step-out sample from SG38 was collected from 6.5 feet bgs.)
- USCS soil type in the vadose zone. As noted in Figures 9 through 11, the soil type in the vadose zone at the site is primarily silty clay. This evaluation assessed the impact of considering the vadose zone USCS soil type as either silty clay or clay. It was concluded that the assumption of clay as the vadose zone USCS soil type produced slightly higher (more conservative) risk and hazard results (see Appendix F, Tetra Tech 2004); therefore, remaining soil gas modeling assumed that the USCS soil type in the vadose zone was clay.
- Soil dry bulk density, total porosity, and water-filled porosity values for clay in the vadose zone were obtained from the model's lookup tables.

The calculations for the evaluation of soil gas vapor transport are presented in Appendix F of the SWMUs 2, 5, 7, and 18 RI report (Tetra Tech 2004).

As shown in the table below, the estimated incremental risk from vapor intrusion to indoor air exceeded 1E-06 for TCE (1.6E-06) and PCE (2.8E-05); cis-1,2-DCE is not considered a potential carcinogen, and the hazard quotients for all three compounds are less than 0.1.

INCREMENTAL RISKS AND HAZARD QUOTIENTS ASSOCIATED WITH MAXIMUM DETECTED CONCENTRATIONS IN SOIL GAS

Compound	Maximum Detected Soil Gas Concentration ($\mu g/m^3$)	Incremental Risk	Hazard Quotient
cis-1,2-DCE	8,100	Not applicable	2.1E-02
TCE	19,000	1.6E-06	3.0E-03
PCE	120,000	2.8E-05	3.1E-01

Notes:

$\mu g/m^3$ Micrograms per cubic meter
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene

Incremental risks associated with TCE and PCE were further evaluated based on maximum detected concentrations in soil gas in the RI report (Tetra Tech 2004). Cis-1,2-DCE presents no incremental risk and an insignificant hazard quotient under site-specific conditions.

4.3 Screening Results

The results of the qualitative HHRA screening indicate that maximum concentrations of COPCs do not exceed residential PRGs. Table 6 presents a comparison of the maximum detected concentrations in soil with PRGs. In addition, maximum concentrations of COPCs in groundwater samples did not exceed the screening levels for inhalation exposure through indoor air.

The on-site maximum detected concentrations in groundwater for cis-1,2-DCE, PCE, and TCE were above MCLs (California Department of Health Services 2000). All other concentrations of COPCs in groundwater were below MCLs. The tap water PRGs (EPA 2002) for benzene; bromodichloromethane; chloroform, 1,2-DCA; PCE; and TCE were also exceeded. Although the site is not currently used as a source of drinking water, a conservative screening against drinking water criteria was performed following guidance in the basin plan (Water Board 1995) and amendments (Water Board 2000) described in Section 2.5.3.

The results of the qualitative HHRA indicate that concentrations of contaminants in groundwater exceed agency threshold levels of concern for drinking water. Residual contaminant concentrations in soil and groundwater samples are below published health-protective values developed considering direct exposure to soil and indirect exposure to VOCs in groundwater.

The Johnson and Ettinger vapor transport model assumes the presence of a residential building measuring 10 by 10 meter (approximately 33 by 33 feet) for calculating potential incremental risks and hazard quotients; therefore, the indoor air quality within this residential building is unlikely to contain only VOCs migrating into the building from the soil gas sampling location where the maximum concentrations was detected. Instead, indoor air concentrations are likely the cumulative result of VOCs migrating from soil gas beneath the entire building footprint.

A box was drawn around soil gas sampling locations close to the former waste oil UST and surrounding the two locations (SG25 and SG31) where the highest soil gas concentrations were detected to assess the incremental risks and hazard quotients associated with soil gas beneath a residential building. This box measures about 33 by 46 feet and encompasses eight soil gas sampling locations (SG25, SG28, SG29, SG31, SG32, SG36, SG37, and SG38). The table below summarizes sample-specific soil gas concentrations and overall detection frequencies and arithmetic average concentrations (calculated assuming a value equal to one-half the detection limit for nondetect results reported as “U”) for TCE and PCE.

SAMPLE-SPECIFIC SOIL-GAS CONCENTRATIONS AND OVERALL DETECTION FREQUENCIES AND ARITHMETIC AVERAGE SOIL GAS CONCENTRATIONS

Soil Gas Sampling Location	TCE ($\mu g/m^3$)	PCE ($\mu g/m^3$)
34SG25	2,400 (M)	15,000 (S)
34SG28	50 U (M)	50 U (M)
34SG29	50 U (M)	50 U (M)
34SG31	19,000 (M)	120,000 (M)
34SG32	50 U (M)	75 (M)
34SG36	26.2 (S)	40.7 (S)
34SG37	7.1 (S)	16.6 (S)
34SG38	12.6 (S)	66.9 (S)
Detection Frequency	5/8 (62.5 percent)	6/8 (75 percent)
Arithmetic Average Concentration	2,690	16,906

Notes:

$\mu g/m^3$ Micrograms per cubic meter
M Analyzed by mobile laboratory
S Analyzed by stationary laboratory
U Not detected
PCE Tetrachloroethene
TCE Trichloroethene

Based on the arithmetic average concentrations in soil gas, the incremental risk for PCE (3.9E-06) exceeds 1E-06, while the incremental risk for TCE (2.2E-07) is less than 1E-06 (see Appendix F, Tetra Tech 2004).

Back-calculating from the PCE results ([16,906 $\mu g/m^3$ x 1E-06]/3.9E-06) indicates that a concentration of PCE in soil gas of 4,286 $\mu g/m^3$ is associated with an incremental risk of 1E-06 for a residential exposure scenario. PCE was detected at concentrations that exceed this concentration only at sampling locations SG25 and SG31. Coincidentally, the maximum detected concentrations of cis-1,2-DCE and TCE were also measured at these same locations.

Finally, incremental risk associated with potential exposure to PCE in indoor air was further evaluated assuming future industrial rather than residential land use. Industrial land-use calculations were performed using EPA's SG-ADV model modified to reflect DTSC's toxicity factor values (EPA 2003; DTSC 2003). The same model assumptions used to assess residential risk were applied for the industrial risk assessment, with the exceptions listed below.

- Averaging time for noncarcinogens was modified from 30 to 25 years.
- Exposure duration was modified from 30 to 25 years.
- Exposure frequency was modified from 350 to 250 days per year.

- The commercial building footprint was modified to 1,056 by 1,056 cm and a ceiling height of 244 cm (Michigan Department of Environmental Quality [MDEQ] 2001).

- Indoor air exchange rate was increased from 0.45 per hour to 2 per hour (MDEQ 2001).

Using an average concentration of PCE in soil gas of 16,906 $\mu g/m^3$, the incremental risk associated with potential exposure to PCE under a future industrial scenario is 3.5E-08 (Tetra Tech 2004). This result does not exceed the target risk of 1E-06.

5.0 RESULTS OF SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

A screening-level ecological risk assessment (SLERA) was conducted during the RI to assess the potential risks to ecological receptors associated with exposure to chemicals of potential ecological concern (COPEC) in soil and groundwater at the site. Results from the SLERA are presented in the RI (Tetra Tech 2004).

This screening-level approach used conservative assumptions and available scientific literature to evaluate ecological risk in an approach consistent with steps 1 and 2 of the eight-step process described in EPA guidance (EPA 1997). The SLERA consists of four primary phases: (1) problem formulation, (2) exposure estimation, (3) evaluation of ecological effects, and (4) risk characterization. An ecological conceptual site model (CSM) was developed for exposure pathways at the site, and assessment and measurement endpoints were selected during the problem formulation phase. Exposure parameters were established for representative receptors identified during the problem formulation and exposure estimation phases. Contaminant exposure levels that represent conservative thresholds for adverse ecological effects were identified during the evaluation of ecological effects. Finally, the potential risks to selected assessment endpoints associated with the site were conservatively estimated during the risk characterization phase.

Adequate information was available to evaluate the potential risk to receptors from COPECs at the site using a screening-level approach. The results of the SLERA are summarized below.

- No significant risk to plants, terrestrial invertebrates, or herbivorous mammals is expected from soil COPECs at the site.
- No significant risk to fish and aquatic invertebrates is expected from groundwater COPECs at the site.

No further action is recommended to characterize ecological risk at the site.

6.0 FEASIBILITY STUDY APPROACH

The FS process includes the following basic steps:

- Develop remedial action objectives that identify contaminants and media of concern, exposure pathways, and remediation goals. Remedial action objectives are developed on the basis of ARARs and the results of the HHRA and ERA.
- Develop general response actions for each medium to address the remedial action objectives. Consider containment, treatment, removal, or other actions singly or in combination in developing general response actions.
- Identify the volume of each affected medium of concern.
- Identify and screen technologies for each general response action to eliminate technologies that technically cannot be implemented or are not cost-effective.
- Identify and screen process options for each technology.
- Assemble retained process options into alternatives and screen the alternatives.
- Conduct a detailed evaluation and comparative analysis of the remaining alternatives identified in the NCP at Title 40 CFR § 300.430(e)(9).

Remedial action objectives and remedial goals were developed for the FS based on the information presented in the RI and the ARARs. Although remedial goals may be established for soil based on planned reuse the Navy prefers to evaluate site cleanup based on unrestricted reuse, when feasible. For the purposes of this FS, remedial goals are established based on the use of residential exposure scenario assumptions for unrestricted reuse.

Remedial action objectives can be achieved either by reducing concentrations of the chemicals of concern (COC) or by eliminating the exposure pathways. This FS evaluation includes remedial alternatives that encompass both approaches.

Each remedial alternative is evaluated individually in the last step of the FS process described in the previous list, and then all the remedial alternatives are evaluated together according to the nine criteria described in the bulleted list that follows. This analysis identifies the relative advantages and disadvantages of each alternative. The first two criteria relate directly to the statutory requirements each remedial alternative must meet and are categorized as threshold criteria. The next five criteria are the primary balancing criteria and are the basis for the preliminary selection of the remedy. Together, these first seven criteria are considered the evaluation criteria. The remaining two criteria, state and community acceptance, are modifying criteria that are applied after comments are received on the proposed alternatives from state agencies and the public.

Threshold Criteria

- Overall protection of human health and the environment – Describes how each alternative protects human health and the environment and indicates how each hazardous substance source is to be eliminated, reduced, or controlled
- Compliance with ARARs – Assesses the compliance of an alternative with all chemical-specific, action-specific, and location-specific ARARs.

Evaluation Criteria

- Long-term effectiveness and permanence – Examines the protection of human health and the environment after construction and implementation of the remedial alternative. This criterion addresses the long-term adequacy, reliability, and permanence of the remedial alternative. Components of this analysis include the following:
  - The expected long-term reduction in risk posed by the site
  - The level of effort needed to maintain the remedy and monitor the area for changes in site conditions
- Reduction of toxicity, mobility, and volume through treatment – Examines the effectiveness of the remedial alternative in reducing the toxicity, mobility, and volume of contaminants through treatment. The following factors are considered:
  - The amount of hazardous materials destroyed or treated
  - The degree of expected reduction in toxicity, mobility, or volume
  - The degree to which the benefits of the remedial alternative are irreversible
  - The types and quantities of treatment residuals that remain after treatment
- Short-term effectiveness – Examines the protection of community and worker health, as well as protection of the environment during construction and implementation of the remedial alternative. The following factors are considered:
  - Protection of the community during the remedial alternative, including the effects of potential releases from the site, transportation of contaminated materials, and air-quality impacts from on-site treatment
  - Protection of workers during the remedial alternative
  - Environmental impacts of the remedial alternative
  - Time required to achieve remedial action objectives
- Implementability – Considers the technical and administrative feasibility of each alternative as well as the availability of the resources required. Factors considered in assessing this criterion include construction and operation and maintenance (O&M) of the remedial alternative; required approvals and permits from regulatory agencies; availability of required off-site treatment or disposal services; and availability of necessary equipment, materials, personnel, and time for implementation.

- Cost – Involves development and evaluation of the capital cost of construction, equipment, land, buildings, engineering services, and project administration as well as O&M costs for labor, spare parts, materials, and administration activities. The present worth of each alternative is calculated using a discount rate in this FS. The level of detail employed in developing these estimates is considered appropriate for making choices among alternatives, but the estimates are not intended for use in detailed budgetary planning. The expected accuracy ranges for development of costs for detailed analysis alternative phase of the FS are –30 to +50 percent (EPA 1988).

- State acceptance – Identifies the state's preferences or concerns about alternatives. This criterion will be evaluated after comments have been received on this FS.

- Community acceptance – Identifies the community's preferences or concerns about alternatives. This criterion will be evaluated after comments have been received on this FS.

Two other criteria are mentioned in the NCP for evaluating each alternative:

- Cost-effectiveness, where costs are compared with overall effectiveness for proportionality. Overall effectiveness comprises long-term effectiveness and permanence, reduction of toxicity, mobility, and volume through treatment, and short-term effectiveness.

- Use of permanent solutions and alternative treatment technologies, or resource recovery technologies to the maximum extent possible, with an emphasis on long-term effectiveness, and reduction of toxicity, mobility, and volume through treatment, and a preference for treatment and bias against off-site disposal.

7.0 FEASIBILITY STUDY EVALUATION

This section describes the development and analysis of remedial alternatives for groundwater at SWMUs 2, 5, 7, and 18. Section 7.1 discusses remedial action objectives. Section 7.2 discusses ARARs, and Section 7.3 discusses general response actions. Section 7.4 identifies the volumes of contaminated groundwater. Section 7.5 presents the preliminary screening of technologies and response actions. Section 7.6 presents the proposed remedial alternatives. Section 7.7 presents a detailed analysis of the remedial alternatives and Section 7.8 presents a comparative analysis of remedial alternatives for SWMUs 2, 5, 7, and 18.

7.1 REMEDIAL ACTION OBJECTIVES

The remedial action objectives to prevent exposures to future residential receptors at SWMUs 2, 5, 7, and 18 are as follows:

- Prevent potential future indoor intrusion of vapors that contain PCE at concentrations that exceed the residential inhalation criteria developed in the RI (Tetra Tech 2004).
- Prevent domestic use of groundwater containing PCE, TCE, and 1,2-DCE at concentrations that exceed California MCLs.

Remedial action objectives also consider ARARs. Development of these remedial action objectives, including a discussion of the exposure pathways, COCs, and remedial goals, is presented in the following sections.

7.1.1 Exposure Pathways

With unrestricted land use, VOCs present in groundwater at SWMU 2, 5, 7, and 18 pose a potential risk to future residential receptors through the following pathways:

- Domestic use of groundwater (ingestion, dermal contact, and inhalation)
- Inhalation of indoor vapors.

No unacceptable ecological risks were identified for SWMUs 2, 5, 7, and 18.

7.1.2 Chemicals of Concern

SWMUs 2, 5, 7, and 18 have been recommended for further evaluation in this FS to address risks to residential receptors under the unrestricted reuse scenario. The COCs and associated exposure pathways that apply are marked with an (X) for each site in the following table:

Chemical of Concern[a]	Groundwater Domestic Use	Indoor Vapor Inhalation
PCE	X	X
TCE	X	X
Cis 1,2-DCE	X	--

Notes:

a Vinyl chloride does not exceed screening levels and does not pose a human health or ecological risk at current levels. However, vinyl chloride could be produced as a degradation product of PCE, TCE, and cis-1,2-DCE by reductive dechlorination.

-- Not applicable
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene

Vinyl chloride could be produced as a degradation product of PCE, TCE, and 1,2-DCE if biologically mediated reductive dechlorination took place within the groundwater at SWMUs 2, 5, 7, and 18. Vinyl chloride has not been detected in any groundwater samples collected to date at SWMUs 2, 5, 7, and 18. In addition, groundwater within SWMUs 2, 5, 7, and 18 contains dissolved oxygen at concentrations of 0.9 to 8.0 mg/L. Reductive dechlorination typically does not occur in groundwater with concentrations of dissolved oxygen exceeding 0.5 mg/L (Wiedemeier and others 1996). Therefore, vinyl chloride is not likely to be produced at SWMUs 2, 5, 7, and 18 under current conditions and will not be considered a COC. However, a remedial goal will be established for vinyl chloride that can be applied if a remedial alternative that stimulates reductive dechlorination is selected.

7.1.3 Remedial Goals

The soil gas remedial goals to protect inhalation of indoor air under a future residential exposure pathway are as follows:

Chemical of Concern	Soil Gas Remedial Goals to Protect Indoor Air Pathway (μg/m^3)
PCE	4,286 [a]
TCE	1,200 [b]
1,2-DCE	7,300 [b]
Vinyl Chloride	31 [b]

Notes:

-- Not applicable
a Based on an exposure scenario of adult/child resident in a one-story residence at SWMUs 2, 5, 7, and 18 (Tetra Tech 2004).
b Based on environmental screening levels (Water Board 2003).
μg/m^3 Micrograms per cubic meter
DCE Dichloroethene
PCE Tetrachloroethene
TCE Trichloroethene

The remedial goal for soil gas of 4,286 μg/m^3 for PCE for inhalation of indoor air under residential exposure scenario assumptions corresponds to a 1.0E-6 excess cancer risk based on the input of site-specific conditions to the Johnson and Ettinger model. The residential exposure scenario consists of an adult or child resident living in a small, one-story building with a concrete slab foundation (Tetra Tech 2004). The remedial goal for soil gas for TCE for inhalation of indoor air corresponds to an environmental screening level developed by the Water Board based on the Johnson and Ettinger model (Water Board 2003). These remedial goals will be applied within the source area (the area of the former waste oil UST near Building IA-12), where concentrations in soil gas have exceeded screening criteria.

The remedial goals for the domestic use and inhalation of indoor air exposure pathways for groundwater are as follows:

Chemical of Concern	Target Groundwater Concentrations to Protect the Indoor Air Pathway		Remedial Goals for Domestic Use of Groundwater (μg/L)[c]	Selected Remedial Goals for Groundwater (μg/L)
	Water Board Environmental Screening Levels to Protect Indoor Air[a] (μg/L)	EPA Guidance for Indoor Air[b] (μg/L)		
PCE	520	5	5	5
TCE	2,100	5	5	5
1,2-DCE	20,000	210	6	6
Vinyl Chloride	17	2	0.5	0.5

Notes:

a Based on environmental screening levels (Water Board 2003).

b Based on U.S. Environmental Protection Agency (EPA). "OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils." November 29. Cited values are from Table 2c for $1x10^{-6}$ risk and are based on the assumption that the indoor air attenuation factor = 0.001 and partitioning across the water table obeys Henry's law.

c Based on California state maximum contaminant levels.

-- Not applicable

μg/L Micrograms per liter

DCE Dichloroethene

PCE Tetrachloroethene

TCE Trichloroethene

The remedial goals for domestic use of groundwater are the California MCLs for PCE, TCE, cis 1,2-DCE, and vinyl chloride. Two sets of target groundwater concentrations to protect the indoor air pathway are presented above. The Water Board environmental screening levels (ESL) represent concentrations in groundwater that are protective of indoor air for residential land use (Water Board 2003). Groundwater ESLS to address potential vapor intrusion were developed for coarse-grained, high-permeability and fine-grained, low-permeability soils. Based on the fine-grained soils that are present in the vadose zone at SWMUs 2, 5, 7, and 18, the ESLS for low-permeability zone soils are applied. Target concentrations for groundwater from EPA guidance are also presented (EPA 2002). These EPA values are based on 10-6 risk and assume that the indoor air attenuation factor is 0.001 and that partitioning across the water table obeys Henry's law. The target concentrations for groundwater to protect indoor air are less than or equal to the remedial goals for domestic use of groundwater. Therefore, the remedial goals for domestic use of groundwater are also protective of the indoor air pathway and were selected as the remedial goals.

7.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ARARs that affect the alternatives at SWMUs 2, 5, 7, and 18 are discussed in the following sections and are summarized in Tables 9 and 10.

7.2.1 Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements

Chemical-specific ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical cleanup values. These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the ambient environment that is protective of human health and the environment. No chemical-specific ARARs have been identified for soil. Chemical-specific ARARs for groundwater are identified in Table 9.

Federal MCLs and maximum contaminant level goals (MCLG) developed by EPA under the Safe Drinking Water Act (SDWA) are potential relevant and appropriate requirements for aquifers with Class I and Class II characteristics, and therefore are potential federal ARARs. MCLs and MCLGs may be considered relevant and appropriate as remediation goals for current and potential sources of drinking water.

The Navy has determined that the California MCLs will be applied to groundwater at SWMUs 2, 5, 7, and 18. The following primary and secondary state MCLs are set forth in Title 22 of the Code of California Regulations (CCR):

- § 64431 (Maximum Contaminant Levels – Inorganic Chemicals).
- § 64444 (Maximum Contaminant Levels – Organic Chemicals), and
- § 64449(a) Secondary Maximum Contaminant Levels).

The Navy has determined that the substantive provisions of the standards of Section (§) 64444 constitute potential relevant and appropriate state ARARs. California MCLs are relevant and appropriate and have been identified as chemical-specific ARARs.

7.2.2 Potential Location-Specific Applicable or Relevant and Appropriate Requirements

Location-specific ARARs are restrictions on the concentrations of hazardous substances or the conduct of activities as a result of the characteristics of the site or its immediate environment. For example, the location of the site or proposed removal action in a flood plain, wetland, historic place, or sensitive ecosystem may trigger potential location-specific ARARs. The

Endangered Species Act, National Historic Preservation Act, and Archeological and Historic Preservation Act were considered potential location-specific ARARs.

The site consists of active industrial areas with no significant ecological habitat. Most of the ground surface at the site is paved; however, some unpaved areas exist. These areas are predominately bare ground, although some non-native annual grasses are present. No surface water is present except as sheet runoff during storm events. No special status plants or animals are known to occur at the site. Therefore, the Endangered Species Act was not considered an ARAR. SWMUs 2, 5, 7, and 18 do not encompass any historic properties included or eligible for inclusion on the National Register of Historic Places. No scientific, prehistoric, or archeological data have been identified at SWMUs 2, 5, 7, and 18. Therefore, no location-specific ARARs have been identified for SWMUs 2, 5, 7, and 18.

7.2.3 Potential Action-Specific Applicable or Relevant and Appropriate Requirements

Action-specific ARARs are technology- or activity-based requirements or limitations for remedial activities. These requirements are triggered by the specific remedial activities conducted at the site and suggest how a selected remedial alternative should be achieved. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be conducted.

Potential action-specific ARARs for SWMUs 2, 5, 7, and 18 are presented in Table 10.

RCRA is a potential ARAR for active treatment alternatives. Any waste generated will be characterized to determine whether it is a hazardous waste. Any hazardous waste accumulated on site, including waste contained in groundwater, must comply with the RCRA requirements set forth at Title 22 CCR § 66262.34. This section permits on-site hazardous waste accumulation for up to 90 days as long as the waste is properly stored and labeled. The following RCRA requirements are potential ARARs for hazardous waste sent off site for disposal at a disposal facility: the RCRA pretransport regulations at Title 22 CCR §§ 66262.30 (packaging), 66262.31 (labeling), 66262.32 (marking) and 66262.33 (placarding), and the RCRA manifest requirements at §§ 66262.20, 66262.21, 66262.22, and 66262.23. In addition, the RCRA hazardous waste manifest requirements at Title 22 CCR §§ 66262.20, 66262.21, 66262.22 and 66262.23 are also potential ARARs.

The Federal Hazardous Materials Transportation Law, Title 49 United States Code (U.S.C.) §§ 5101-5127, and its implementing regulations are ARARs for transporting hazardous waste and include representations that containers are safe, prohibitions on altering labels, and requirements for marking, labeling, and placarding.

Potential ARARs specifically for groundwater alternatives at SWMUs 2, 5, 7, and 18 include the SDWA underground injection requirements. Injection wells used as part of the application of hydrogen releasing compounds (HRC) will be designated Class V wells in accordance with Title 40 CFR §§ 144.6(e) and 144.12, which prohibit injection of substances that allow movement of contaminants into underground sources of drinking water that may result in violations of MCLs or adversely affect health.

7.3 GENERAL RESPONSE ACTIONS

General response actions are broad classes of responses or remedial actions intended to meet the remedial action objectives. The following five general response actions were identified to achieve the remedial action objectives for SWMUs 2, 5, 7, and 18:

- **No Action –** Under the no-action alternative, no remedial measures will be taken at the site.
- **LUCs –** LUCs are nonengineered instruments such as administrative or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use.
- **Engineering Controls –** Engineering controls reduce or eliminate potential exposures of human and ecological receptors to contamination by preventing contact with contaminated media.
- **MNA –** This technology involves natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials that are allowed to reduce contaminant concentrations to acceptable levels. Monitoring is required to confirm that the processes are reducing contaminant concentrations.
- **Active Remediation –** This category encompasses engineering instruments that reduce or eliminate the potential exposures of human receptors to contamination by reducing contaminant toxicity, volume, or mobility through treatment or by excavating and disposing of contaminants off site.

7.4 VOLUMES OF CONTAMINATED MEDIA

The estimated area of groundwater that requires remediation is 208,650 square feet. This area is based on the domestic use remedial goal of 5 µg/L for PCE and is outlined by the 5 µg/L contour on Figure 13. The volume of contaminated groundwater was calculated using the following formula:

$$V_{gw} = 7.48\ A\ T\ n$$

where

V_{gw}	is the volume of contaminated groundwater in gallons
A	is the area of the contamination based on domestic remedial goals in square feet
T	is the thickness of the contaminated groundwater in feet
n	is the effective porosity of the aquifer

A contaminated aquifer thickness of 15 feet was estimated for SWMUs 2, 5, 7, and 18. Assuming an effective aquifer porosity of 0.28, the estimated volumes of contaminated groundwater are as follows:

Plume	Volume of Contaminated Groundwater	
	cubic feet	million gallons
SWMUs 2, 5, 7, and 18 (Area of Plume with PCE Concentrations > 5 μg/L)	208,650	6.6
SWMUs 2, 5, 7, and 18 (Area of Plume with PCE Concentrations > 10 μg/L)	30,000	0.9

Notes:
μg/L Micrograms per liter
PCE Tetrachloroethene

7.5 PRELIMINARY SCREENING OF TECHNOLOGIES AND RESPONSE ACTIONS

This section presents the preliminary screening of technologies and response actions to meet the remedial action objectives for SWMUs 2, 5, 7, and 18. Section 7.5.1 presents the screening criteria. Section 7.5.2 identifies, describes, and screens technology and process options. Section 7.5.3 summarizes the retained remedial technologies and process options.

Information about the various treatment technologies discussed in this section was obtained from the following sources:

- EPA guidance on presumptive remedies for contaminated groundwater (EPA 1996)
- Federal Remediation Technologies Roundtable (FRTR) screening matrix on remediation technologies (FRTR 2002)
- NFESC environmental restoration website (NFESC 2002)
- Office of Solid Waste and Emergency Response (OSWER) publication on LUCs (EPA 2000).

7.5.1 Screening Criteria

Various treatment technologies and other response actions were evaluated during the initial screening for their ability to address groundwater contamination. All treatment technologies EPA identified as presumptive remedies for groundwater contaminated by VOCs (EPA 1996) were considered in the preliminary screening of treatment technologies for groundwater. Other treatment technologies were also considered. The screening evaluations focused on each technology's effectiveness in removing contamination, and on its implementability and cost.

7.5.1.1 Effectiveness

The evaluation of effectiveness focused on (1) the ability of the technology to address contaminants of interest, (2) the ability of the technology to meet the remedial goals within a reasonable timeframe, and (3) the reliability of the technology. In terms of remediation timeframe, a technology is classified as short term (achieving the remedial goals after less than 3 years of implementation), medium term (achieving the remedial goals after 3 to 10 years of implementation), or long term (requiring more than 10 years of implementation to achieve the remedial goals) (FRTR 2002).

7.5.1.2 Implementability

The evaluation of implementability considers both the technical and the administrative feasibility of implementing a treatment technology. Technical feasibility includes compatibility with site-specific conditions; the availability of equipment; the ease of constructing the remediation system; the labor intensiveness required by the system; and the availability of vendors that have the capabilities to design, construct, and maintain the system. Administrative feasibility includes the ease of completing permitting processes and obtaining approvals from authorities.

7.5.1.3 Cost

The evaluation of cost addresses direct and indirect capital and annual O&M costs. When the information is available, the cost range is presented quantitatively. Otherwise, qualitative descriptions of low, moderate, and high are used. The terms low, moderate, and high cost describe a unit cost for treatment that is less than $3 per 1,000 gallons (low), $3 to $10 per 1,000 gallons (moderate), and more than $10 per 1,000 gallons (high) (FRTR 2002). The cost ranges are based on a review of the literature, vendor quotations, and data prepared for other studies.

7.5.2 Identification and Screening of Technologies and Response Actions

Technologies and other response actions are described and evaluated against the three preliminary screening criteria described in this section. A summary of the preliminary screening process for groundwater treatment technologies is presented in Table 11.

Technologies were retained based on their demonstration of acceptable levels of effectiveness in treating chlorinated ethenes; implementability; and cost. The no-action and LUCs alternatives are discussed first, followed by an overall evaluation of treatment technologies for groundwater. The following sections identify and present screening the rationale for each of the options that was considered.

7.5.2.1 No Action

No action implies that no remedial action will be conducted on site. Under the no-action alternative, groundwater would be left as is without implementing any LUCs, containment, removal, treatment, or other mitigating actions. This response action would not be effective in reducing potential risks to human health that may result from future exposures to groundwater under unrestricted land use. No cost is associated with this option because no action is taken. The NCP requires that the no-action response be included among the alternatives evaluated in every FS (Title 40 CFR § 300.430[e][6]). The no-action alternative provides a baseline for comparison to the other remedial response actions.

7.5.2.2 Land Use Controls

EPA defines LUCs as "non-engineering measures designed to prevent or limit exposure to hazardous substances left in place at a site, or assure effectiveness of a selected remedy." There are four general categories of LUCs: governmental controls, proprietary controls, enforcement and permit tools with LUC components, and informational devices. LUCs are often more effective if they are layered or implemented in series. Layering means using different categories of LUCs concurrently to enhance the protectiveness of the remedy. Implementation of LUCs in series may be applied to ensure both the short- and long-term effectiveness of the remedy. As a single remedy, LUCs are typically implemented as a long-term approach.

The following subsections describe and evaluate LUCs that could be applied at SWMUs 2, 5, 7, and 18.

Governmental Controls

Governmental controls use the regulatory authority of a government entity to impose restrictions on citizens or property under its jurisdictions. Examples of government controls include restrictions on zoning and groundwater use.

A zoning restriction is a common LUC that specifies allowed land uses for certain areas. Zoning can be used to prevent certain exposures that would not otherwise be prevented under a remedy. Examples of zoning restrictions include (1) prohibition of a site for residential development, or (2) restrictions on excavation at sites to specific depths where contamination is present. Although the zoning restrictions are typically issued by a local government, they are not necessarily permanent. They can be repealed, or local governments can grant exceptions after public hearings. For a long-term remedy, therefore, zoning restrictions are usually layered with other LUC tools. Zoning restrictions are readily implementable at low cost and are, therefore, retained for further evaluation.

Restrictions on groundwater use are typically directed at limiting or prohibiting certain uses of groundwater, which may include limitations or prohibitions on well drilling in a certain area or groundwater extraction from a specific aquifer. The effectiveness of the restrictions on groundwater use depends on the willingness and ability of local governments to monitor compliance and take enforcement action. Similar to zoning restrictions, restrictions on groundwater use are typically layered with other LUC tools. Restrictions on groundwater use are readily implementable, potentially effective, and low cost; therefore, they are retained for further evaluation.

Proprietary Controls

Proprietary controls involve legal instruments placed in the chain of title of the site property. Proprietary controls can be implemented without the intervention of any federal, state, or local regulatory authority. Proprietary controls include easements and covenants.

An easement typically provides access rights to a property so the facility owner or regulatory agency may inspect and monitor the effectiveness of a remediation system. An easement is retained for further evaluation because long-term monitoring is a critical component to assess the effectiveness of the LUC approach. It would be layered with other LUC tools.

A covenant is an agreement between one landowner to another in connection with a conveyance of property to use or refrain from using the property in a certain manner. A major benefit of a covenant is that it can be used in cases where unremediated property is transferred from the current owner to another party. Implementation of a covenant is retained for further evaluation because of the possibility of potential property transfer in the future.

Enforcement Tools with LUC Components

Enforcement tools are defined as authorities, such as administrative orders or consent decrees, available under CERCLA and RCRA that can be applied to restrict land use. Enforcement authority can be used to either (1) prohibit a party from using land in a certain way or from carrying out certain activities at a specified property, or (2) require a settling party to put in place some other form of control, such as a proprietary controls.

These tools are eliminated from further evaluation because they are more difficult to implement than governmental controls and are less appropriate as a long-term solution.

Informational Tools

These tools provide information or notification that residual contamination may remain on site. Common examples include state registries of contaminated properties, deed notices, and advisories. The most commonly used are deed notices, which refers to a nonenforceable, purely informational document filed in public land records. Because they are nonenforceable, however, informational devices are most likely to be used as a secondary layer to enhance the overall reliability of other LUCs.

7.5.2.3 Engineering Controls

Engineering controls reduce or eliminate potential exposures of human and ecological receptors to contamination by preventing contact with contaminated media. The most common methods to control vapor from entering a building are by installing a vapor barrier beneath the building or a ventilation system to remove vapors from beneath the building.

Vapor barriers are a passive approach typically employed during construction. They consist of installing the vapor barrier (6-mil polyethylene or equivalent), sealing plumbing penetrations, mixing floor slab concrete with superplasticizers, reinforcing the slab at reentrant corners, and proper curing and loading the slab.

Ventilation systems typically include a subslab depressurization system. This active approach uses a depressurization fan to lower the pressure below the slab. This negative pressure creates a sink for VOCs beneath the building, and the vapors are collected using the fan in perforated piping in the slab. The fan extracts air from the below the slab and diverts it to ambient air. This response action was eliminated for existing building but was retained for further analysis for new buildings.

7.5.2.4 Monitored Natural Attenuation

This response action involves natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials that are allowed to reduce contaminant concentrations to acceptable levels. This option usually requires modeling and evaluation of contaminant degradation rates and pathways and predicting contaminant concentrations at downgradient receptor points, especially when the plume is still expanding and migrating. The primary objective of site modeling is to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations to below regulatory standards or risk-based levels before potential exposure pathways are completed. In addition, long-term monitoring must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting the remedial goals.

MNA is not sufficiently effective as a single remediation approach to achieve the remedial action objectives. Appendix A presents an evaluation of the time required for MNA to reduce VOC concentrations below remedial goals. More than 250 years would be required for MNA to achieve remedial goals (Appendix A). MNA is therefore eliminated as a single remedial approach, but may be effective to treat residual contamination.

7.5.2.5 Active Soil Remediation

Two technologies were considered during the preliminary screening process as for active soil remediation. These two technologies, which are discussed below, are excavation and off-site disposal, and soil vapor extraction (SVE).

Excavation with Off-site Disposal

Under this approach, contaminated soil is excavated and transported to permitted off-site treatment or disposal facilities. Excavation and off-site disposal is a well-proven and common method for cleaning up hazardous waste sites. Contaminated soil was excavated from the former tank pit during removal of the former waste oil UST, but the excavation could not be continued beneath the existing power pole or beneath Building IA-12. Excavation with off-site disposal is therefore eliminated because excavation of soil beneath Building IA-12 is not implementable.

Soil Vapor Extraction

SVE is an in situ technology that reduces concentrations of volatile contaminants in the vadose zone and, to a lesser degree, may remove strip volatile components from the groundwater. A vacuum is applied to wells near the contaminant source, which causes volatile constituents to be stripped from the soil into vapors and drawn to the wells. The extracted vapor is then treated at the surface through carbon adsorption to remove the volatile constituents. SVE would be able to treat contaminated soil within the area of the former waste oil tank, including contaminated soil beneath Building IA-12, and is retained for consideration.

7.5.2.6 Active Groundwater Remediation

This section presents the technologies that were considered during the preliminary screening process as primary options for active cleanup of contaminated groundwater. The primary technologies discussed below include pump and treat, air sparging with SVE, biosparging, in situ chemical oxidation (ISCO), thermal treatment (steam flushing), a passive treatment wall, enhanced in situ bioremediation, and zero-valent iron (ZVI) injection.

Pump and Treat with Air Stripping

Groundwater pumping can be used to extract groundwater for treatment by ex situ treatment technologies. Long timeframes are often needed to remove contaminants through groundwater pumping (FRTR 2002), and large capital and O&M costs often are required to implement these systems. Pump and treat is a presumptive remedy for VOCs in groundwater (EPA 1996) and is retained for further consideration. However, other treatment technologies are expected to be effective but with shorter remediation times and lower cost.

Air stripping is a process that has been widely used to remove VOCs from water. Extracted groundwater is treated at the surface, typically in packed towers. Air stripping is effective in removing the chlorinated compounds found at the site and is therefore retained for further analysis.

Pump and Treat with Chemical or Ultraviolet Light Oxidation

This technology would use chemical or ultraviolet (UV) light oxidation at the surface to remove VOCs from extracted groundwater. Chemical or UV oxidation was eliminated because air stripping is expected to provide similar removal of VOCs at a lower cost.

Pump and Treat with Carbon Adsorption

This technology would pump extracted groundwater through canisters of activated carbon to remove VOCs. The VOCs would be adsorbed to the activated carbon. This technology would require periodic replacement or regeneration of the activated carbon. Carbon adsorption was eliminated because air stripping is expected to provide similar removal of VOCs from extracted groundwater at a lower cost.

Air Sparging with Soil Vapor Extraction

Air sparging is an in situ treatment technology that is implemented by injecting pressurized air into a contaminated aquifer so that air streams traverse horizontally and vertically through the soil column, creating an underground stripper that removes contaminants by volatilization. The injected air and entrained contaminants are removed from the subsurface by a vapor extraction system. The extracted soil vapor is then treated at the surface by carbon adsorption to remove VOCs. This technology is designed to operate at high flow rates to strip the VOCs from groundwater.

Air sparging is generally not effective at sites with clay or highly stratified soils or a confined aquifer (EPA 1994). Clay and silty clay soils have been described in numerous borings sampled at SWMUs 2, 5, 7, and 18 (Tetra Tech 2004). Therefore, air sparging may not be effective or may be effective only over limited areas of the site. Air sparging is generally considered effective in soils with an intrinsic permeability greater than 10E-09 square centimeters (EPA 1994).

The average hydraulic conductivity of saturated soils as measured in slug tests conducted at SWMUs 2, 5, 7, and 18 is 4.0 feet per day (Section 2.6.3). Therefore, the intrinsic permeability of the saturated soil is 1.4E-08 square centimeters. Air sparging with soil vapor extraction is retained; however, a pilot study will be required to evaluate the effectiveness of air sparging with soil vapor extraction before it can be implemented.

Biosparging

Biosparging is similar to air sparging except that air is injected at a much lower flow rate and vapor collection is not needed. This technology relies on adequate distribution of air through the subsurface. The effectiveness of biosparging is limited in treating TCE and PCE, two of the major groundwater contaminants at SWMUs 2, 5, 7, and 18, and, therefore, is not retained.

In Situ Chemical Oxidation

ISCO involves injecting chemical oxidants into the vadose zone or groundwater (or both) to oxidize contaminants to carbon dioxide, water, and chloride ions. The hydroxyl radicals associated with ISCO would react with and effectively destroy the halogenated compounds of concern at the site. The chemical oxidants most commonly employed to date include peroxide, ozone, permanganate, Fenton's reagent (hydrogen peroxide with iron catalyst), modified Fenton's reagent (a chelated organometallic catalyst), and stabilized peroxide. ISCO was eliminated from further consideration, however, because it is not expected to be cost effective for removal of low concentrations of VOCs over a wide area.

Thermal Treatment (Steam Flushing)

Steam flushing is implemented by forcing steam into an aquifer through injection wells to vaporize VOCs and semivolatile organic compounds (SVOCs). Vaporized components rise to the unsaturated (vadose) zone, where they are removed by vacuum extraction and then treated. Hot water or steam flushing/stripping is a pilot-scale technology. In situ biological treatment may be applied after steam flushing and is continued until contaminant concentrations in groundwater achieve the remedial goals. SVOCs and fuels are the target contaminant groups for steam flushing. VOCs also can be treated by this technology, but there are more cost-effective processes for sites contaminated with VOCs. Furthermore, steam flushing is not recommended for treatment of low-permeability soils. Treatment costs typically range from \$2 to \$6 per gallon of groundwater treated based on a 70 percent on-line efficiency (FRTR 2002). Thermal treatment using steam flushing was eliminated from further consideration because more cost-effective methods are available for VOC removal.

Passive Treatment Wall

This technology involves installing a permeable reaction wall across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. These barriers allow water to pass, while prohibiting movement of contaminants by employing such agents as zero-valent metals, chelators (ligands selected for their specificity for a metal), sorbents, and microbes. The contaminants will either be degraded or retained in a concentrated form by the barrier material.

A common treatment barrier configuration is the funnel-and-gate system. Funnel-and-gate systems for in situ treatment of contaminated plumes consist of low-hydraulic conductivity (for example, 10^{-6} centimeters per second) cutoff walls (the funnel), with a gate that contains reactive porous media. The reactive media remove contaminants by physical, chemical, or biological processes as the groundwater passes through the gate. The types of cutoff walls most likely to be used are slurry walls or sheet piles.

The time required to achieve remedial goals using passive treatment walls typically ranges from 3 to 30 years. An average implementation cost ranges from \$300 to \$1,500 per square foot of reactive barrier installed (assuming a barrier thickness of 2 to 4 feet) (FRTR 2002). Based on the depth to groundwater at SWMUs 2, 5, 7, and 18, the passive treatment wall would be installed at a depth of approximately 25 to 40 feet bgs. This technology was eliminated from further consideration, however, because a passive treatment wall would require long-term monitoring and maintenance.

Enhanced In Situ Bioremediation

HRC and oxygen-releasing compounds (ORC) were both considered as options for enhancing in situ bioremediation at SWMUs 2, 5, 7, and 18.

HRC. HRC is a proprietary polylactate ester formulated for slow release of lactic acid on hydration. The HRC is applied to the subsurface via push-point injection or within dedicated wells. The HRC is then left in place, where it passively works to stimulate rapid contaminant degradation. HRC is injected directly into the aquifer matrix in a grid pattern over the areal extent and across the vertical zone of the contaminant plume. Because of the time-released characteristic, one round of HRC injection will provide the dissolved hydrogen continuously for 6 to 12 months, when reapplication may be needed. Enhanced in situ bioremediation using HRC is effective for halogenated VOCs and is retained.

ORC. ORC is a patented formulation of magnesium peroxide that produces a slow and sustained release of molecular oxygen when in contact with soil moisture or groundwater. The introduction of additional oxygen provides an aerobic environment for naturally occurring microorganisms that aerobically degrade pollutants into less-toxic by-products, ultimately to carbon dioxide and water. ORC may be used directly in the contaminant plume to treat the contaminants dissolved in groundwater and any sorbed to soil below the water table. Since aerobic bioremediation is at least 10 to 100 times faster than anaerobic bioremediation, the ORC application stimulates much faster contaminant reduction rates when compared with unamended natural attenuation, which is generally oxygen deficient. Similar to HRC, ORC is injected directly into the aquifer matrix in a grid pattern over the areal extent and across the vertical zone of the contaminant plume. Enhanced in situ bioremediation using ORC is effective for treating vinyl chloride and 1,2-DCE but would not reduce concentrations of TCE and PCE; therefore, it was not retained.

Zero-Valent Iron Injection

This technology abiotically reduces chlorinated VOCs to daughter products through electron transfer from the ZVI to the chlorinated VOCs or through production of hydrogen gas that dechlorinates the VOCs. ZVI powder is slurried with water and injected throughout the contaminated aquifer through boreholes. The slurry is injected into different intervals under continuous pressure (hydraulic or pneumatic). Before it is injected, each interval may be fractured to improve horizontal dispersion of the ZVI powder. ZVI injection was not retained because it is not effective for benzene and naphthalene, which are COCs at SWMUs 2, 5, 7, and 18. Furthermore, it is higher in cost than air sparging and HRC, which have been retained.

7.5.3 Summary of Retained Remedial Technologies and Response Actions

SVE was the only technology retained to remediate vadose zone contamination in the source area (the area of the former waste oil tank near Building IA-12). Contamination in the vadose zone appears to extend beneath a portion of Building IA-12 in this area. Excavation was eliminated as a technology because excavation beneath Building IA-12 was not considered implementable. SVE was retained because it can effectively treat the vadose zone in situ beneath Building IA-12.

Technologies and other response actions that passed the preliminary screening for groundwater included LUCs, engineering controls, and the following active groundwater treatment technologies:

- Air sparging with soil vapor extraction
- Enhanced in situ bioremediation using HRC
- Pump and treat with air stripping

Table 12 presents a summary of the comparative analysis of treatment technologies for groundwater that were retained from the preliminary screening.

7.6 PROPOSED REMEDIAL ALTERNATIVES

This section presents the proposed remedial alternatives for groundwater at SWMUs 2, 5, 7, and 18. Even though the projected use for the land above the groundwater plumes at SWMUs 2, 5, 7, and 18 is commercial/industrial, the cleanup goals are for unrestricted use. As a result, cleanup to MCLs will be required to protect potential future domestic use of groundwater.

The potential for indoor vapor intrusion of COCs partitioning from groundwater and migrating into existing buildings was not considered in developing the remedial alternatives. They were not considered because the existing buildings at SWMUs 2, 5, 7, and 18 are for commercial/industrial use, and the human health risks from vapor intrusion are acceptable for commercial/industrial land use. This potential vapor intrusion pathway, however, was considered in developing the remedial alternatives for potential future residential buildings.

Five remedial alternatives are proposed. Alternatives 3A and 3B use the same remedial technology but apply it over different treatment areas. Because these two alternatives are similar, they have been designated 3A and 3B. The following remedial alternatives were designed to meet the remedial action objectives that were developed for SWMUs 2, 5, 7, and 18:

PROPOSED REMEDIAL ALTERNATIVES - SWMU 2, 5, 7, AND 18

Alternative 1	**No Action** • Expected to reach domestic use remedial goals in more than 250 years, based on modeling of natural attenuation (Appendix A).
Alternative 2	**Air sparging with soil vapor extraction (SVE) for soil, soil gas, and groundwater** • Use air sparging and SVE for soil, soil gas, and groundwater in the source area (area of former waste oil UST). • Use air sparging and SVE for groundwater throughout the plume where contaminant concentrations exceed MCLs. • Short-term land use controls may be needed during the remediation.
Alternative 3A	**Enhanced bioremediation for groundwater throughout plume and SVE in source area for soil and soil gas** • Use SVE to treat soil and soil gas contamination within source area. • Use enhanced bioremediation to treat groundwater contamination throughout the plume where contaminant concentrations exceed MCLs. • Short-term land use controls may be needed during the remediation.
Alternative 3B	**Enhanced bioremediation for groundwater in main portion of plume and SVE in source area for soil and soil gas** • Use SVE to treat soil and soil gas contamination within source area. • Use enhanced bioremediation to treat groundwater contamination within the area where concentrations of PCE exceed 10 µg/L. • In light of the length of remediation time, LUCs are needed to prevent use of groundwater at the site for drinking water.
Alternative 4	**Pump and treat for groundwater throughout plume and SVE in source area for soil and soil gas** • Use SVE to treat soil and soil gas contamination within source area. • Use pump and treat technology to treat groundwater contamination throughout the plume where contaminant concentrations exceed MCLs. • In light of the length of remediation time, LUCs are needed to prevent use of groundwater at the site for drinking water.

Each of these remedial alternatives is discussed in more detail in Section 7.7.

7.7 DETAILED ANALYSIS OF GROUNDWATER REMEDIATION ALTERNATIVES FOR SWMUS 2, 5, 7, AND 18

A detailed analysis of the SWMUs 2, 5, 7, and 18 groundwater remedial alternatives proposed in Section 7.6 is provided in this section. The application of each alternative to SWMUs 2, 5, 7, and 18 is described, followed by an evaluation of the alternative for the first seven of the nine NCP criteria described in Section 4.0.

7.7.1 Alternative 1: No Action

Under this alternative, there would be no efforts to contain, remove, monitor, or treat the contaminated groundwater at SWMUs 2, 5, 7, and 18. An evaluation of the no-action alternative provides a baseline that can be used to measure the alternatives.

7.7.1.1 Overall Protection of Human Health and the Environment

Concentrations of PCE and TCE in soil gas exceed the remedial goals for future residential land use in the source area near the former waste oil tank adjacent to Building IA-12 (Figure 16). Therefore, Alternative 1 is not considered protective of human health based on the potential for inhalation of indoor vapors that migrate from soil gas into potential future residential buildings.

Groundwater at SWMUs 2, 5, 7, and 18 contains PCE, TCE, and cis-1,2-DCE at concentrations that pose a risk to humans if groundwater were extracted and used for drinking water. With unrestricted reuse, Alternative 1 is not protective of human health because it does not prevent exposure to domestic consumption of groundwater. Domestic use of groundwater, however, is not expected under the planned land use for SWMUs 2, 5, 7, and 18.

Concentrations of VOCs in groundwater at SWMUs 2, 5, 7, and 18 do not pose a risk to humans through indoor vapor intrusion under the current industrial land use scenario. However, target concentrations of PCE and TCE in groundwater exceed the target concentrations to protect the indoor air pathway (ESLs) for a potential future residential land use scenario. Future residential land use is not expected for SWMUs 2, 5, 7, and 18. However, Alternative 1 is not protective of human health because it does not prevent inhalation of indoor vapors that may partition from groundwater and migrate to potential future residential buildings.

7.7.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 1 would meet the chemical-specific ARARS for the site, but the time required would not be acceptable. No location-specific ARARs have been identified, and no action-specific ARARS would apply to this alternative.

7.7.1.3 Long-term Effectiveness and Permanence

Alternative 1 does not provide a mechanism to prevent extraction and domestic use of groundwater, which could result in exposure of human receptors who ingest the groundwater. Alternative 1 also does not provide a mechanism to prevent indoor vapor intrusion of PCE and TCE from soil gas at SWMUs 2, 5, 7, and 18 under a future residential land use scenario.

Based on modeling presented in Appendix A, the estimated time to reach remedial goals for domestic use based on natural attenuation is more than 250 years at SWMUs 2, 5, 7, and 18.

7.7.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative would not provide treatment to reduce the toxicity, mobility, or volume of contaminants at SWMUs 2, 5, 7, and 18. However, this alternative would eventually meet the remedial action objectives through natural degradation processes.

7.7.1.5 Short-Term Effectiveness

There would be no risks to the community or workers during implementation because this alternative would not involve any action. The remedial action objectives for soil and groundwater would not be achieved in a protective and timely manner; therefore, the no-action alternative is considered ineffective in the short term.

7.7.16 Implementability

This alternative is easily implemented because no action would be conducted and additional resources are not required.

7.7.1.7 Cost

No capital or O&M costs are associated with Alternative 1.

7.7.2 Alternative 2: Air Sparging with Soil Vapor Extraction

Alternative 2 consists of air sparging to inject air into the saturated zone to strip VOCs from the groundwater into the injected air. An SVE system recovers the air and entrained VOCs as the air migrates upward into the vadose zone. No separate treatment technology is needed to address VOCs in the vadose zone within the area of the former waste oil tank near Building IA-12 because Alternative 2 includes SVE to treat the vadose zone. Figure 17 shows the area of treatment for Alternative 2. Groundwater would be treated until concentrations of the COCs are reduced to below remedial goals for domestic use.

The full-scale air sparging system would include approximately 375 sparge wells. The SVE system would include 250 SVE wells. Alternative 2 is expected to require 4 years to complete, which includes 2 years for treatment followed by 2 years of groundwater monitoring.

7.7.2.1 Overall Protection of Human Health and the Environment

Alternative 2 would protect human health and the environment by reducing concentrations of chlorinated compounds in groundwater to below remedial goals for domestic use. No significant risk to ecological receptors was identified in the RI (Tetra Tech 2004).

7.7.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 2 would comply with all chemical-, location- and action-specific ARARs identified for this alternative.

7.7.2.3 Long-term Effectiveness and Permanence

Alternative 2 is expected to attain remedial goals for domestic use in 4 years and provide long-term effectiveness and permanence. Based on its performance at other sites, Alternative 2 is expected to attain remedial goals for domestic use in shallow groundwater in 2 years for all COCs, with 2 years of groundwater monitoring afterward to confirm that remedial goals have been achieved. Since the chlorinated ethenes would be removed from groundwater by stripping and extracted in the vapor, the chlorinated ethenes will not degrade to vinyl chloride. Concentrations of vinyl chloride do not currently and are not expected to exceed remedial goals in the future under existing conditions. Therefore, the remedial goals for PCE, TCE, and 1,2-DCE would apply.

7.7.2.4 Reduction of Mobility, Toxicity, or Volume through Treatment

Air sparging with SVE would reduce the mobility, toxicity, and volume of contaminants in groundwater by removing and treating VOCs. However, VOCs would be treated with granular activated carbon, which would require disposal at a disposal facility.

7.7.2.5 Short-term Effectiveness

Alternative 2 is expected to reduce the concentrations of VOCs in groundwater to remedial goals for domestic use within 2 years, followed by 2 years of groundwater monitoring. VOCs would be recovered in air by the SVE system and treated at the surface. Potential hazards from emissions of VOCs from the SVE system would be mitigated by engineering controls and by following health and safety procedures during operation and maintenance of the system. In addition, use and disposal of spent granular activated carbon with adsorbed VOCs would be mitigated through proper storage, handling, transport, and disposal of the waste. Short-term land use controls may be needed during remediation.

7.7.2.6 Implementability

Implementability includes technical and administrative feasibility and the availability of the resources required. This alternative is technically feasible.

7.7.2.7 Cost

The estimated total present worth cost for Alternative 2 at SWMUs 2, 5, 7, and 18 is $4.4 million, and does not include LUCs that would be necessary if the site were to transfer before remedial goals for domestic use are reached. The basis and a detailed estimated cost for this alternative are presented in Appendix B.

7.7.3 Alternative 3A: Soil Vapor Extraction in Source Area and Enhanced In Situ Bioremediation with Hydrogen Release Compound for Groundwater

Alternative 3A consists of soil vapor extraction to treat VOC contamination in soil and soil gas in the source area and enhanced bioremediation using HRC treatment of groundwater at SWMUs 2, 5, 7, and 18. Groundwater would be treated by HRC throughout the plume where concentrations of PCE exceed 5 μg/L until the concentrations are reduced to below remedial goals for domestic use. Figure 18 shows the treatment area for Alternative 3A.

Implementation of enhanced bioremediation using HRC on groundwater at SWMUs 2, 5, 7, and 18 would require primary and secondary treatment, with a single injection for each treatment. Each treatment would last between 12 and 18 months. Groundwater samples would be collected and analyzed quarterly for the duration of treatment and quarterly for 2 years after the final injection event to determine whether concentrations rebound.

In addition to the groundwater treatment system, an SVE system would be used in the source area to treat contamination in the vadose zone. The SVE system would include one SVE well in the area of the former waste oil tank pit near Building IA-12, a blower, and an activated carbon canister to treat extracted vapor.

Alternative 3A is expected to require 5 years to complete because HRC treatment may require up to 3 years, followed by 2 years of groundwater monitoring. A pilot test would be required to evaluate the technology and optimize treatment.

7.7.3.1 Overall Protection of Human Health and the Environment

Alternative 3A would protect human health and the environment by reducing concentrations of PCE in soil gas to meet remedial goals for indoor inhalation and by reducing concentrations of chlorinated compounds in groundwater to below remedial goals for domestic use. No significant risk to ecological receptors was identified in the RI (Tetra Tech 2004).

7.7.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3A would comply with all chemical-, location- and action-specific ARARs identified for this alternative.

7.7.3.3 Long-term Effectiveness and Permanence

Alternative 3A would provide long-term effectiveness and permanence. Alternative 3A is expected to attain remedial goals for domestic use in 3 years or less. However, it is possible that a longer time may be required to reach the remedial goal of 0.5 µg/L for vinyl chloride, since vinyl chloride is a degradation product of the chlorinated ethenes. If the remedial goals are not reached after secondary treatment of shallow groundwater by HRC, then additional treatment may be required.

7.7.3.4 Reduction of Mobility, Toxicity, or Volume through Treatment

Enhance bioremediation using HRC would reduce the toxicity and the volume of contaminants by promoting degradation of toxic chemicals to less toxic or nontoxic products.

7.7.3.5 Short-term Effectiveness

Enhanced bioremediation using HRC should reduce the concentrations of the COCs to the remedial goals for domestic use in 3 years or less for all COCs, except possibly vinyl chloride, where the remedial goal is 0.5 µg/L. The use of HRC presents no temporary hazards during transport and application of the treatment agent.

Potential hazards posed by VOC emissions from the SVE system would be mitigated by engineering controls and by following health and safety procedures during operation and maintenance of the system. In addition, use and disposal of spent granular activated carbon with adsorbed VOCs would be mitigated through proper storage, handling, transport, and disposal of the waste. Short-term land use controls may be needed during remediation.

7.7.3.6 Implementability

Implementability includes technical and administrative feasibility and the availability of required resources. This alternative is technically feasible. Several HRC injections, however, would likely be necessary to achieve the remedial goals for domestic use.

7.7.3.7 Cost

The estimated total present worth cost for Alternative 3A is $ 1.9 million. The basis and a detailed estimated cost for this alternative are presented in Appendix B.

7.7.4 Alternative 3B: Soil Vapor Extraction in Source Area and Enhanced In Situ Bioremediation with Hydrogen Release Compound for Groundwater

Alternative 3B consists of soil vapor extraction to treat VOC contamination in soil and soil gas in the source area and enhanced bioremediation using HRC of groundwater at SWMUs 2, 5, 7, and 18. Groundwater would be treated by HRC in the area of the plume where concentrations of PCE exceed 10 µg/L. Figure 19 shows the treatment area for Alternative 3B.

Implementation of enhanced bioremediation using HRC would require primary and secondary treatment, with a single injection for each treatment. Each treatment would last between 12 and 18 months. Groundwater samples would be collected and analyzed quarterly for the duration of the treatment and quarterly for 2 years after the final injection event to determine whether concentrations rebound.

In addition to the groundwater treatment system, an SVE system would be used in the source area to treat contamination in the vadose zone. The SVE system would include one SVE well in the area of the former waste oil tank pit near Building IA-12, a blower, and an activated carbon canister to treat extracted vapor.

Alternative 3B is expected to require 20 years to complete. Enhanced bioremediation using HRC treatment is expected to achieve remedial goals within 5 years in the area of treatment, but achieving remedial goals in the downgradient area may require 20 years. Groundwater monitoring would be conducted over the 20-year time frame to monitor the effects of treatment in the source area on concentrations of VOCs in the area downgradient. A pilot test would be required to evaluate the most effective parameters for the treatment.

7.7.4.1 Overall Protection of Human Health and the Environment

Alternative 3B would protect human health and the environment by reducing concentrations of PCE in soil gas to meet remedial goals for indoor inhalation and by reducing concentrations of chlorinated compounds in groundwater to below remedial goals for domestic use. LUCs for groundwater extraction would protect potential receptors until contaminant concentrations are reduced to below remedial goals for domestic use. No significant risk to ecological receptors was identified in the RI (Tetra Tech 2004).

7.7.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3B would comply with all chemical-, location- and action-specific ARARs identified for this alternative.

7.7.4.3 Long-term Effectiveness and Permanence

Alternative 3B would eventually provide long-term effectiveness and permanence. Alternative 3B is expected to attain remedial goals for domestic use in 20 years. LUCs would be needed to prevent domestic use of groundwater for this alternative.

7.7.4.4 Reduction of Mobility, Toxicity, or Volume through Treatment

Enhanced bioremediation using HRC would reduce the toxicity and the volume of contaminants by promoting degradation of toxic chemicals to less toxic or nontoxic products.

7.7.4.5 Short-term Effectiveness

Alternative 3B would reduce the concentrations of the COCs to the remedial goals for domestic use within the treatment area, but would not achieve remedial goals throughout the site for at least 20 years. HRC presents no temporary hazards during transport and application of the treatment agent.

Potential hazards from VOC emissions from the SVE system would be mitigated by engineering controls and by following health and safety procedures during operation and maintenance of the system. In addition, use and disposal of spent granular activated carbon with adsorbed VOCs would be mitigated through proper storage, handling, transport, and disposal of the waste.

7.7.4.6 Implementability

Implementability includes technical and administrative feasibility and the availability of the resources required. Alternative 3B is technically feasible. Several HRC injections, however, would likely be necessary to achieve the remedial goals for domestic use within the treatment area.

7.7.4.7 Cost

The estimated total present worth cost for Alternative 3B is $ 2.2 million. The basis and a detailed estimated cost for this alternative are presented in Appendix B.

7.7.5 Alternative 4: Soil Vapor Extraction in Source Area and Pump and Treat with Air Stripping for Groundwater

Alternative 4 consists of soil vapor extraction to treat VOC contamination in soil and soil gas in the source area and pumping groundwater and treatment with air stripping. Figure 19 shows the areas of treatment and the proposed system of extraction and monitoring wells. Groundwater would be treated until concentrations of COCs are reduced to below remedial goals for domestic use. Implementation of pump and treat would require at least 16 extraction wells (Figure 19). Additional extraction wells may be needed if the system does not achieve sufficient hydraulic control of the VOC plume. The wells would be installed with 15-foot screens installed across the water table to extract shallow groundwater. Each of the wells would be pumped at 3 gallons per minute. Slug testing (Tetra Tech 2004) indicated a hydraulic conductivity of approximately 4 feet per day. Alternative 4 is expected to require 20 years to complete.

The Navy may transfer the site before the remedial goals for domestic use are reached because the pump and treat remediation timeframe is expected to be approximately 20 years. In this case, LUCs for groundwater extraction would be necessary to protect potential receptors until contaminant concentrations are reduced to below remedial goals for domestic use.

7.7.5.1 Overall Protection of Human Health and the Environment

Alternative 4 would protect human health and the environment by reducing concentrations of PCE in soil gas to meet remedial goals for indoor inhalation and by reducing concentrations of chlorinated compounds in groundwater to below remedial goals for domestic use. LUCs for groundwater extraction would protect potential receptors until contaminant concentrations are reduced to below remedial goals for domestic use. LUCs that require vapor barriers would protect the indoor inhalation pathway. No significant risk to ecological receptors was identified in the RI (Tetra Tech 2004).

7.7.5.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all chemical-, location- and action-specific ARARs identified for this alternative.

7.7.5.3 Long-term Effectiveness and Permanence

Alternative 4 is expected to attain remedial goals for domestic use in 20 years.

7.7.5.4 Reduction of Mobility, Toxicity, or Volume through Treatment

Pump and treat would reduce the mobility of contaminants by establishing hydraulic control over the plume. SVE would reduce the mobility of PCE in soil gas by removing and treating soil vapor. The toxicity and volume of contaminants in groundwater would be reduced by groundwater extraction and air stripping to remove VOCs at the surface.

7.7.5.5 Short-term Effectiveness

Pump and treat with air stripping would require approximately 20 years to reduce the concentrations of VOCs in groundwater to remedial goals for domestic use. Therefore, the short-term effectiveness of Alternative 4 is limited.

Potential hazards from VOC emissions from the SVE system would be mitigated by engineering controls and by following health and safety procedures during operation and maintenance of the system. In addition, use and disposal of spent granular activated carbon with adsorbed VOCs would be mitigated through proper storage, handling, transport, and disposal of the waste.

7.7.5.6 Implementability

Implementability includes technical and administrative feasibility and the availability of the resources required. Alternative 4 is technically feasible.

7.7.5.7 Cost

The estimated total present worth cost for Alternative 4 is $ 12 million, but does not include LUCs that would be necessary if the site were to transfer before remedial goals for domestic use are reached. The basis and a detailed estimated cost for this alternative are presented in Appendix B.

7.8 COMPARATIVE ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES FOR SWMUS 2, 5, 7, AND 18

This section presents a comparative analysis of the remedial alternatives this FS proposes for remedial alternatives for groundwater at SWMUs 2, 5, 7, and 18. The comparative analysis of remedial alternatives evaluates the relative performance of Alternatives 1 through 4 against seven of the nine specific NCP evaluation criteria presented in Section 4.1. The comparative analysis of remedial alternatives for groundwater is summarized in Table 13.

This comparative analysis identifies the relative advantages and disadvantages of each alternative and thereby provides a sound basis for remedy selection that is consistent with the NCP. The NCP states, "The national goal of the remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste."

7.8.1 Overall Protection of Human Health and the Environment

Alternative 1 is not protective of human health because it does not prevent future exposure to domestic consumption of groundwater and it does not prevent inhalation of indoor vapors that may migrate to future residential buildings.

Each of the alternatives protects human health by reducing contaminant concentrations in groundwater to below remedial goals for domestic use; however, Alternatives 2 and 3A accomplish that goal more rapidly than Alternatives 3B and 4. Alternatives 3B and 4 therefore require the use of LUCs to prevent use of groundwater for potential future domestic use until remedial goals are reached by active remediation.

Alternatives 2 through 4 would all use SVE to treat VOCs in the vadose zone in the area of the former waste oil tank near Building IA-12. SVE treatment will reduce soil gas concentrations to levels that are also protective of the indoor air inhalation pathway.

No unacceptable ecological risks have been identified at SWMUs 2, 5, 7, and 18, so none of the alternatives is intended to mitigate risks to the environment.

7.8.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 1 would not comply with ARARs. Alternatives 2 through 4 would comply with the ARARs identified in this report.

7.8.3 Long-term Effectiveness and Permanence

Alternative 1 would not provide long-term effectiveness and permanence for groundwater at SWMUs 2, 5, 7, and 18.

Alternatives 2 and 3A provide a remedy with long-term effectiveness and permanence by actively treating contamination to reach remedial goals for domestic use of groundwater and indoor vapor intrusion within 4 and 5 years. Short-term LUCs may be needed during remediation but no long-term LUCs are expected to be necessary for these two alternatives.

Alternatives 3 and 4 would eventually provide long-term effectiveness and permanence, but the time to achieve remedial goals is 20 years. LUCs would be needed to prevent domestic use of groundwater for both these alternatives.

7.8.4 Reduction of Mobility, Toxicity, or Volume through Treatment

Alternative 1 would eventually reduce the mobility, toxicity, and volume of contamination through natural degradation processes; however, the time required is more than 250 years. Alternatives 2 through 4 would reduce the mobility, toxicity, and volume of contamination through active groundwater treatment.

7.8.5 Short-term Effectiveness

Alternative 1 would not introduce a risk to the community or the environment because no action would be taken. Under Alternatives 2, 3A, 3B, and 4, VOCs would be recovered in air by the SVE system and treated at the surface. Potential hazards from VOC emissions from the SVE system would be mitigated by engineering controls and by following health and safety procedures during operation and maintenance of the system. The SVE system would most likely use granular activated carbon, and so would require proper storage, handling, transport, and disposal of the GAC waste. Alternatives 2, 3A, 3B, and 4 are not expected to pose risks to the community or the environment.

7.8.6 Implementability

Alternative 1 would be easy to implement because it requires no action. Alternatives 2 through 4 are implementable.

7.8.7 Cost

Estimated total capital costs for each alternative are summarized in the following text and in Table 13. These estimates were prepared to include capital cost of construction, equipment, land, buildings, engineering services, and project administration as well as O&M costs for labor, spare parts, materials, and administration activities. Actual costs would depend on actual labor rates, productivity, the final project schedule, and other variable factors. The estimates are not intended for use in detailed budgetary planning. Consistent with EPA guidance, accuracy ranges for development of costs for detailed analysis alternative phase of the FS are within the range of –30 to +50 percent (EPA 1988). The costs for Alternatives 2, 3, and 4 are as follows:

	No Action	Alternative 2	Alternative 3A	Alternative 3B	Alternative 4
Remediation Time Frame[a]	>250 years	4 years	5 years	20 years	20 years
Cost (in millions)[b]	$0	$ 4.4	$ 1.9	$ 2.2	$ 12

Note:

a The remediation time frame includes 2 years of groundwater monitoring to confirm that remedial goals have been reached.
b Estimated costs are rounded to two significant figures.

7.8.8 Summary of Comparative Analysis

Alternative 1, no action, provides the lowest degree of protectiveness and is not acceptable as a result. Alternatives 2 through 4 would each protect human health and would each comply with ARARs.

The costs and remediation time frames for the alternatives are shown in the above table. Alternative 2 would achieve the remedial goals within the shortest time frame but is approximately 2 times the cost of Alternatives 3A and 3B. Alternative 3A is the lowest cost alternative and would achieve the remedial goals within 5 years at a cost of $1.9 million. Alternative 3B is the next lowest cost alternative but would take approximately 20 years to reach remedial goals. Alternative 4 is the highest-cost alternative and would take the longest time to reach remedial goals.

8.0 CONCLUSIONS

The Navy will use this FS to prepare a proposed plan for public comment. The proposed plan will recommend one of the alternatives identified in this FS. After regulatory and community acceptance have been considered, the Navy will issue a record of decision that sets forth the selected final remedy.

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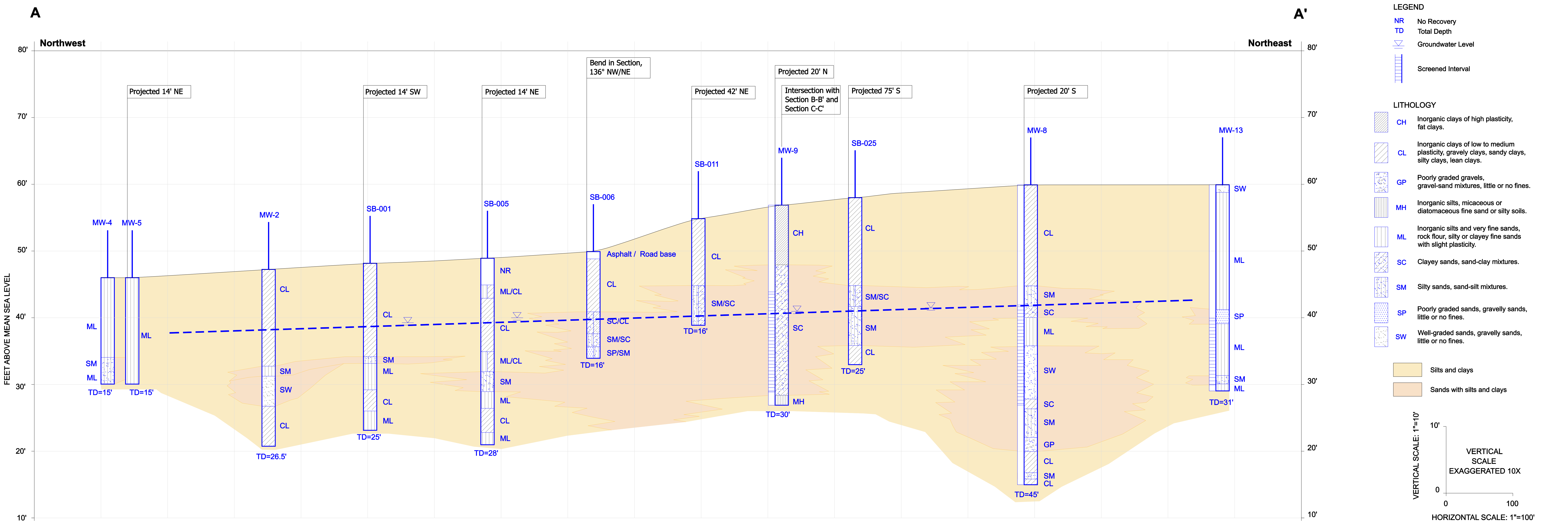
FIGURES

Figures 1 to 5

These detailed station maps have been deleted from the Internet-accessible version of this document as per Department of the Navy Internet security regulations.



NOTES:

Groundwater level information is projected from data presented in Figure 15 "Site Potentiometric Surface Map SWMUS 2, 5, 7, and 18 Remedial Investigation (March 2002).

Ground surface elevations of soil borings are approximated.

This hydrogeologic cross-section is based on interpretation of borings. Actual conditions may vary

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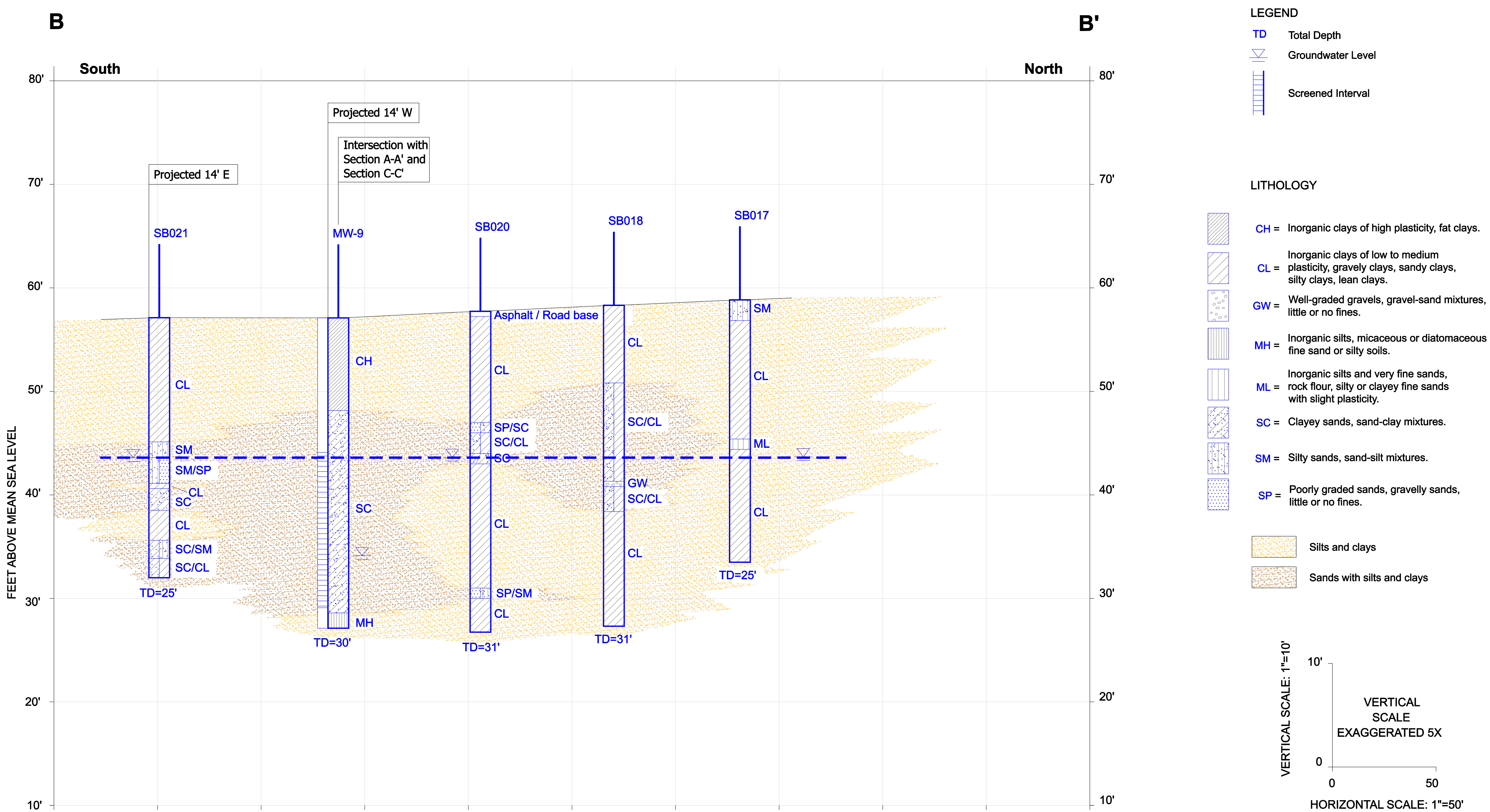
Naval Weapons Station Seal Beach Detachment
Concord, California
Integrated Product Team West, Daly City

FIGURE 6
HYDROGEOLOGIC CROSS-SECTION A-A'

SWMUs 2, 5, 7, and 18 Feasibility Study



NOTES:

Groundwater level information is projected from data presented in Figure 15 "Site Potentiometric Surface Map SWMUS 2, 5, 7, and 18 Remedial Investigation (March 2002).

Ground surface elevations of soil borings are approximated.

This hydrogeologic cross-section is based on interpretation of borings. Actual conditions may vary

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FIGURE 7
HYDROGEOLOGIC CROSS-SECTION B-B'

SWMUs 2, 5, 7, and 18 Feasibility Study

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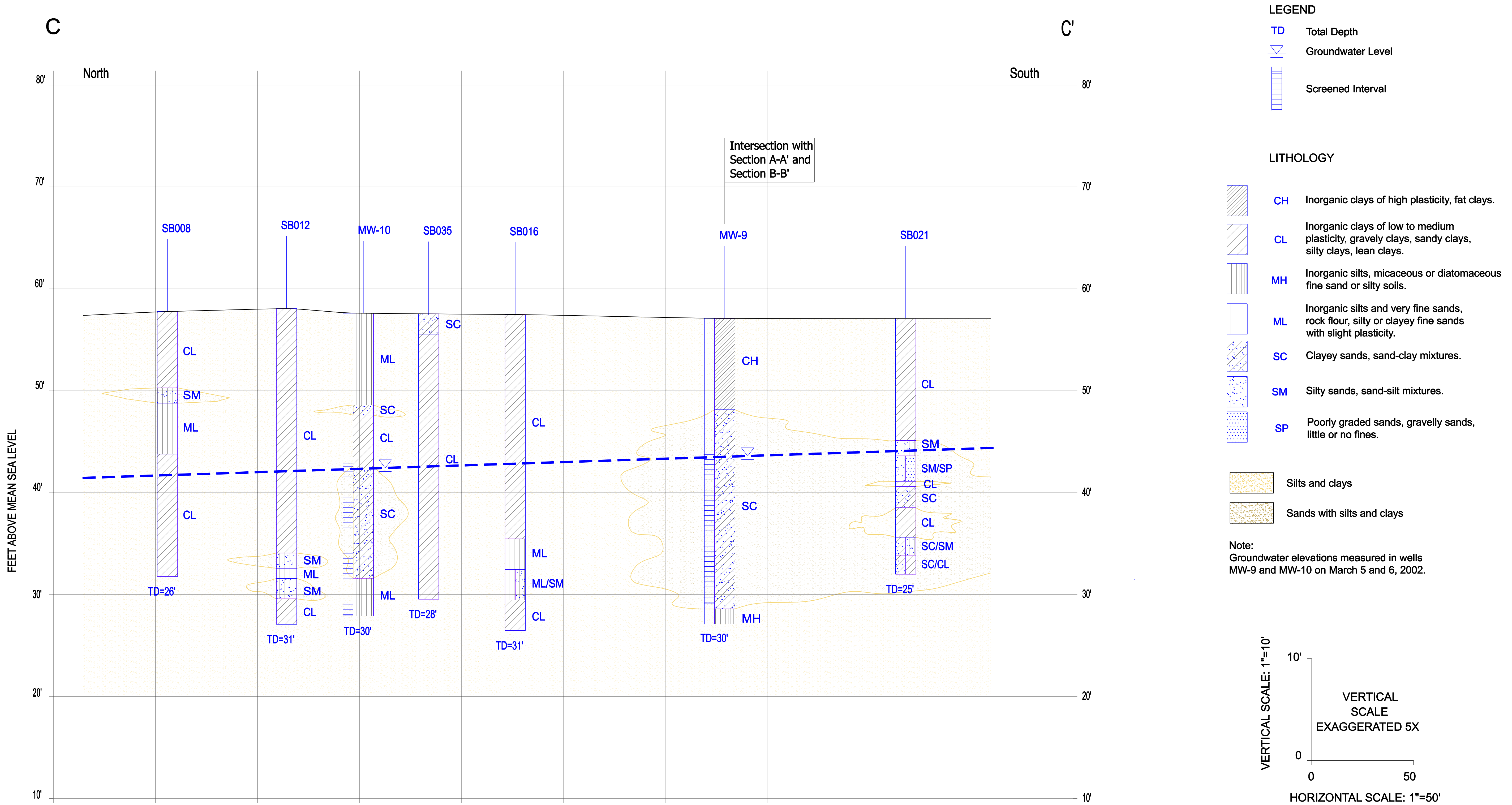

NOTES:

Groundwater level information is projected from data presented in Figure 15 "Site Potentiometric Surface Map SWMUS 2, 5, 7, and 18 Remedial Investigation (March 2002).

Ground surface elevations of soil borings are approximated.

This hydrogeologic cross-section is based on interpretation of borings. Actual conditions may vary

Naval Weapons Station Seal Beach Detachment
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FIGURE 8
HYDROGEOLOGIC CROSS-SECTION C-C'

SWMUs 2, 5, 7, and 18 Feasibility Study

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Figures 9 to 20

These detailed station maps have been deleted from the Internet-accessible version of this document as per Department of the Navy Internet security regulations.

TABLES

TABLE 1: AQUIFER SLUG TEST RESULTS

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

	Monitor Well Parameters					Hydrogeology		Test Parameters								Results	
Well Name	Well Diameter (inches)	TOC Elevation (feet msl)	Top of Filter Pack (feet bgs)	Top of Screen (feet bgs)	Bottom of Screen (feet bgs)	Lithology of Saturated Portion of Screen Interval (USCS)	Expected Range of Hydraulic Conductivity (feet/day)	Static Water Level (feet toc)	Height of Water Column (feet)	Volume of Water Column[a] (gallons)	Total Displacement (feet)	Total Volume of Displacement (gallons)	Percent of Water Column Displacement (%)	Volume of Water Removed (gallons)	Recovery Time (minutes)	Hvorslev Hydraulic Conductivity (feet/day)	Bouwer & Rice Hydraulic Conductivity (feet/day)
MW-2	2	NA	NA	NA	26.3[b]	NA	NA	9.42	17.0	24.9	8.91	1.5	6.0	1.00	2.8	3.7	2.9
MW-7	2	61.9	19	20	30	CL/MH	0.0001 to 1[c] 0.001 to 1[d]	17.69	13.4	19.7	4.38	0.71	3.6	0.38	0.45	126	90
MW-8	2	60.7	17	18	33	SW	0.1 to 50[c] 0.001 to 1[d]	16.21	16.8	24.7	5.35	0.87	3.5	0.63	1.8	9.3	6.8
MW-9	2	57.2	12	13	28	SC	0.001 to 1[c] 0.001 to 0.1[d]	14.64	13.4	19.6	4.89	0.80	4.1	0.35	10	1.7	1.2
MW-10	2	58.2	14	15	30	SC	0.001 to 1[c] 0.001 to 0.1[d]	16.60	13.4	19.7	4.64	0.76	3.9	0.38	3.8	6.6	4.5
MW-11	2	49.4	7.5	8.5	18.5	CL/MH	0.001 to 0.1[c] 0.001 to 1[d]	9.86	11.7	17.2	3.57	0.58	3.4	0.44	0.75	47.5	32.9
MW-13[e]	2	64.3	20	20	31	SP/SM/ML	0.1 to 50[c] 0.001 to 10[d]	2.08[f]	28.9	42.5	8.03	1.31	3.1	0.88	>12	2.7	2.2
													GEOMETRIC MEAN[g]:			**4.0**	**3.0**

Notes:

a Includes the volume of water in the well filter pack.
b Bottom of screen assumed to equal the total depth of the well as measured during the test. The screen length was assumed to equal 15 feet based on other well screen lengths.
c U.S. Department of the Interior. 1989. Basic Ground-Water Hydrology. U.S. Geological Survey Water-Supply Paper 2220.
d Fetter, C.W. 1988. Applied Hydrogeology, Macmilllian Publishing Company, 2nd Ed.
e Monitor well MW-13 is a flowing artesian well.
f Static water level measured from the top of a 38-inch polyvinyl chloride riser pipe attached to the top of casing.
g Because the slug test results for monitoring wells MW-7 and MW-11 are not representative of native material, they are excluded from the calculation of the geometric mean.

bgs Below ground surface
msl Mean sea level
NA Not available
toc Top of casing
USCS Unified Soil Classification System

Lithology Descriptions:
CL Inorganic clays of low to medium plasticity (gravelly, sandy, silty, lean clays)
MH Inorganic silts, micaceous or diatomaceous fine sand or silty soils
ML Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayer silts with slight plasticity
SC Clayey sands, sand/clay mixtures
SM Silty sands, sand/silt mixtures
SP Poorly graded sands, gravelly sands (little or no fines)
SW Well-graded sands, gravelly sands (little or no fines)

TABLE 2: STATISTICAL SUMMARY OF ANALYTICAL RESULTS FOR SOIL

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Analyte [a]	Number of Detections/ Number of Samples	Detection Frequency (Percent)	Minimum Value Detected	Maximum Value Detected	Location of Minimum Value	Location of Maximum Value
Petroleum Hydrocarbons (mg/kg)						
Gasoline range organic compounds	3/134	2.2	0.04 J	960 H	SB016	SB020
Diesel range organic compounds	19/133	14.3	4 J	1,700 D	SB001	SB020
Motor oil range organic compounds	22/133	16.5	5 J	750 M	SB001	SB024
Volatile Organic Compounds (mg/kg)						
1,2,4-Trimethylbenzene	3/158	1.9	0.0008 J	21.1	SB022	SB020
1,3,5-Trimethylbenzene	2/158	1.3	0.26 J	5.7	SB020	SB020
4-Methyl-2-pentanone	10/158	6.3	0.0007 J	0.003 J	SB005	SB008
Ethylbenzene	1/158	0.6	0.0006 J	0.0006 J	SB023	SB023
Isopropylbenzene	1/158	0.6	0.8	0.8	SB020	SB020
M,p-xylenes	5/158	3.2	0.0007 J	0.42 J	SB022	SB020
Naphthalene	2/158	1.3	0.46 J	2.8	SB020	SB020
P-Isopropyltoluene	3/158	1.9	0.0039 J	7.5	SB001	SB020
sec-Butylbenzene	2/158	1.3	0.9	5.7	SB020	SB020
Tetrachloroethene	2/158	1.3	0.0006 J	0.002 J	SB024	SB018
Toluene	12/158	7.6	0.0006 J	0.26 J	SB036	SB020
Trichloroethene	1/158	0.6	0.001 J	0.001 J	SB018	SB018

Notes:

a Categories of analyses are shown, but only detected compounds are presented

D Chromatographic pattern resembles diesel
H Chromatographic pattern is in the heavier hydrocarbon end of the analyte's range in the standard
J Estimated value
M Chromatographic pattern resembles motor oil
mg/kg Milligram per kilogram

TABLE 3: STATISTICAL SUMMARY OF ANALYTICAL RESULTS FOR GROUNDWATER

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Analyte [a]	Number of Detections/ Number of Samples	Detection Frequency (Percent)	Minimum Value Detected	Maximum Value Detected	Location of Minimum Value	Location of Maximum Value
Petroleum Hydrocarbons (µg/L)						
Gasoline range organic compounds	3/21	14.3	30 ZJ	100	SB020	SB024
Diesel range organic compounds	8/18	44.4	50 J	420 D	SB025	SB018
Motor oil range organic compounds	4/18	22.2	60 J	2,200 M	SB027	SB033
Volatile Organic Compounds (µg/L)						
1,1-Dichloroethene	1/48	2.1	1	1	MW-9	MW-9
1,2,4-Trimethylbenzene	5/48	10.4	1	2	SB003	SB001
1,2-Dichloroethane	1/48	2.1	0.4 J	0.4 J	MW-9	MW-9
1,3,5-Trimethylbenzene	4/48	8.3	0.3 J	0.6 J	SB011	SB001
4-Methyl-2-pentanone	1/48	2.1	0.9 J	0.9 J	SB006	SB006
Benzene	2/48	4.2	0.5 J	0.5 J	SB001	SB001
Bromodichloromethane	1/48	2.1	1	1	SB001	SB001
Carbon Disulfide	1/48	2.1	0.3 J	0.3 J	SB022	SB022
Chlorodibromomethane	1/48	2.1	0.9 J	0.9 J	SB001	SB001
Chloroform	2/48	4.2	0.4 J	1	MW-14	SB001
Cis-1,2-dichloroethene	9/48	18.8	0.5 J	7 J	SB012	SB024
Ethylbenzene	7/48	14.6	0.4 J	1	SB028	SB001
M,p-Xylenes	9/48	18.8	0.3 J	6	SB016	SB001
Methyl tertiary butyl ether	3/48	6.3	0.5 J	2 J	SB021	SB013
Naphthalene	4/48	8.3	0.3 J	0.5 J	SB003	SB011
O-Xylene	7/48	14.6	0.5 J	3	SB021	SB029
P-Isopropyltoluene	1/48	2.1	0.6 J	0.6 J	SB001	SB001

TABLE 3: STATISTICAL SUMMARY OF ANALYTICAL RESULTS FOR GROUNDWATER (Continued)

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Analyte [a]	Number of Detections/ Number of Samples	Detection Frequency (Percent)	Minimum Value Detected	Maximum Value Detected	Location of Minimum Value	Location of Maximum Value
Volatile Organic Compounds (µg/L) (Continued)						
Tetrachloroethene	25/48	52.1	0.4 J	100	MW-9	MW-10
Toluene	18/48	37.5	0.3 J	9	SB009	SB001
Trans-1,2-dichloroethene	7/48	14.6	0.3 J	4 J	SB023	SB024
Trichloroethene	23/48	47.9	0.5 J	38 J	SB006	SB024

Notes:

a Categories of analyses are shown, but only detected compounds are presented.
D Chromatographic pattern resembles diesel
J Estimated value
M Chromatographic pattern resembles motor oil
µg/L Microgram per liter
Z Chromatographic pattern does not resemble total petroleum hydrocarbon (TPH) fuel pattern (individual peaks)

TABLE 4: SOIL GAS RESULTS FROM MOBILE LABORATORY

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

SAMPLE ID	RWQCB Screening Level (See Note 3)	Ambient Blank	324SG01	324SG02	324SG03	324SG04	324SG05	324SG06	324SG07	324SG08	324SG09	324SG10	324SG11	324SG12	324SG13	324SG14	324SG15	324SG16	324SG17	324SG17	324SG18	324SG19	324SG20
SAMPLE DEPTH			5	5	5	5	5	5	5	10	5	10	5	5	5	5	10	5	5	5 duplicate	5	5	5
Benzene	84	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	15,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	410	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	650	ND	ND
Toluene	83,000	ND	220	180	ND	130	290	ND	ND	110	90	160	58	220	90	53	130	70	ND	ND	ND	180	200
1,1,1-Trichloroethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	1,200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Xylenes	21,000	ND	240	180	70	97	210	60	ND	81	75	100	58	230	100	85	86	65	ND	ND	100	170	220
Carbon Disulfide		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,2-Dichloroethene	7,300	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4: SOIL GAS RESULTS FROM MOBILE LABORATORY (Continued)

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

SAMPLE ID	324SG21	324SG22	324SG23	324SG23	324SG24	324SG25	324SG25	324SG26	324SG27	324SG28	324SG29	324SG30	324SG31	324SG32	324SG32	324SG33	324SG34	324SG34	Method Blank	Method Blank	Method Blank	Method Blank
SAMPLE DEPTH	5	5	5	5 duplicate	10	5	5 summa duplicate sample	5	5	5	10	5	5	5	10	5	5	5 duplicate				
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,100	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	12,000	14,000	ND	ND	ND	ND	ND	120,000	75	150	730	ND	ND	ND	ND	ND	ND
Toluene	230	180	160	150	210	ND	ND	160	130	120	130	170	180	80	65	180	51	85	160	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	2,400	2,200	ND	ND	ND	ND	ND	19,000	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Xylenes	210	170	160	160	170	ND	ND	150	130	80	60	130	180	89	83	70	ND	100	170	ND	ND	ND
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	650	ND	ND	ND	ND	ND	8,100	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

1 All results reported in micrograms per cubic meter.
2 The detection limits vary for each constituent. Detection limits are presented in Appendix A-3.
3 From Interim Final July 2003 SFBRWQCB screening levels for evaluation of indoor air impacts from shallow soil gas in sandy soil. Screening level is for "Lowest Residential" exposure scenario
4 Blue highlight dentotes constituent detection.
5 Yellow highlight denotes concentration exceeding RWQCB screening level

RWQCB San Francisco Bay Regional Water Quality Control Board

TABLE 5: SOIL GAS RESULTS FROM STATIONARY LABORATORY

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

SAMPLE ID	RWQCB Screening Level (See Note 3)	324SG04	324SG05	324SG09	324SG18	324SG21	324SG25	324SG32	324SG35	324SG36	324SG37	324SG37 (field dup.)	324SG37 (lab dup.)	324SG38	324SG39
SAMPLE DEPTH		**5**	**5**	**5**	**5**	**5**	**5**	**10**	**5**	**5**	**5**	**5**	**5**	**6.5**	**5**
Freon 12	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 114	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	31	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	1,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	2,900	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 11	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	42,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	2,400	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	1,500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichoroethene	7,300	ND	ND	ND	ND	ND	550	ND	ND	15	5.4	ND	ND	ND	ND
Chloroform	460	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	46,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	58	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	84	2.9	3.0	ND	ND	11	ND	4.2	2.6	3.2	3.6	ND	ND	3.9	2.9
1,2-Dichloroethane	120	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	1,200	ND	ND	ND	68	ND	2,200	ND	ND	26	7.1	ND	ND	12	ND
1,2-Dichloropropane	240	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	150	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	83,000	12	11	6.0	ND	25	ND	9.5	15	14	17	9.2	8.5	19	12
trans-1,3-Dichloropropene	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	150	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	410	ND	ND	ND	1,000	ND	15,000	25	ND	40	17	6.8	6.9	67	ND
1,2-Dibromoethane (EDB)	34	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	13,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	2,200	ND	ND	ND	ND	4.0	ND	4.3	5.4	5.2	5.4	3.8	4.1	6.5	6.1
m,p-Xylene	None Available	8.8	7.8	5.2	ND	15	ND	18	25	21	25	16	17	27	26
o-Xylene	None Available	ND	ND	ND	ND	5.3	ND	6.8	9.6	7.3	8.4	5.5	5.4	9.1	8.1
Total Xylenes	21,000	8.8	7.8	5.2	ND	20.3	ND	24.8	34.6	28.3	33.4	21.5	22.4	36.1	34.1
Styrene	210,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	None Available	7.2	ND	ND	ND	ND	ND	6.2	8.2	5.6	7.6	7.0	6.5	6.8	7.4
1,3-Dichlorobenzene	670	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	220	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
alpha-Chlorotoluene	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	42,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Butadiene	None Available	ND	ND	ND	ND	ND	ND	3.2	ND	4.4	2.0	ND	ND	ND	2.1
Hexane	None Available	ND	3.4	ND	ND	5.1	ND	3.5	2.7	3.0	ND	ND	ND	ND	ND
Cyclohexane	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.0
Heptane	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	15
Bromodichloromethane	66	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cumene	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 5: SOIL GAS RESULTS FROM STATIONARY LABORATORY (Continued)

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

SAMPLE ID	RWQCB Screening Level (See Note 3)	324SG04	324SG05	324SG09	324SG18	324SG21	324SG25	324SG32	324SG35	324SG36	324SG37	324SG37 (field dup.)	324SG37 (lab dup.)	324SG38	324SG39
SAMPLE DEPTH		**5**	**5**	**5**	**5**	**5**	**5**	**10**	**5**	**5**	**5**	**5**	**5**	**6.5**	**5**
Propylbenzene	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	1,400	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	42,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	73,000	180	370	19	11	700	ND	39	16	45	37	19	19	46	44
Carbon Disulfide	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	41
2-Propanol	None Available	ND	ND	ND	ND	24	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	15,000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Acetate	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone (Methyl Ethyl Ketone)	None Available	25	46	ND	ND	73	ND	ND	ND	11	ND	ND	ND	11	11
Tetrahydrofuran	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dioxane	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexanone	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Ethyltoluene	None Available	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol	None Available	ND	7.5	ND	ND	12	ND	ND	28.0	9.2	55	38	40	42	38
Methyl tert-butyl ether	9,400	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

1 All results reported in micrograms per cubic meter.
2 The detection limits vary for each constituent. Detection limits are presented in Appendix A-3.
3 From Interim Final July 2003 SFBRWQCB screening levels for evaluation of indoor air impacts from shallow soil gas in sandy soil. Screening level is for "Lowest Residential" exposure scenario
4 Blue highlight dentotes constituent detection.
RWQCB San Francisco Bay Regional Water Quality Control Board

TABLE 6: COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS IN SOIL WITH RESIDENTIAL PRELIMINARY REMEDIAL GOALS

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Analyte	Maximum Detection (mg/kg)	Sample Location	Sample Depth (ft)	Sample Date	Residential Screening Value [a] (mg/kg)	Is Maximum Concentration Detected Greater than Screening Value?
1,2,4-Trimethylbenzene	21.1	SB020	6.5	2/22/02	52	No
1,3,5-Trimethylbenzene	5.7	SB020	6.5	2/22/02	21	No
4-Methyl-2-Pentanone	0.003	SB008	6.0	2/2102	790	No
Bis(2-ethylhexl)phthalate	8.8	MW-9	10.5	2/1/99	35	No
Ethylbenzene	0.0006	SB023	6.0	2/22/02	8.9	No
Isopropylbenzene	0.8	SB020	6.5	2/22/02	140	No
M,P-Xylenes	0.42	SB020	6.0	2/22/02	270	No
Naphthalene	2.8	SB020	6.5	2/22/02	56	No
Phenol	0.096	MW-08	5.5	1/27/99	37000	No
P-Isopropyltoluene [b]	7.5	SB020	6.5	2/22/02	520	No
sec-Butylbenzene	5.7	SB020	6.5	2/22/02	220	No
PCE	0.002	SB018	28	2/25/02	1.5	No
Toluene	0.26	SB020	6.0	2/22/02	520	No
TCE	0.001	SB018	28	2/25/02	0.0053	No

Notes:

a U.S. Environmental Protection Agency, Region IX, "Preliminary Remedial Goals," October 2002

mg/kg Milligram per kilogram
PCE Tetrachloroethene
TCE Trichloroethene

TABLE 7: COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS IN GROUNDWATER WITH SCREENING LEVELS FOR PROTECTION OF HUMAN HEALTH

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Analyte	Maximum Detection 2002 Sampling Event (µg/L)	Sample Locations	Indoor Air Screening Value [a] (µg/L)	MCL [b] (µg/L)	EPA 2002 Guidance for Indoor Air [c] (µg/L)	2002 Tap Water PRG Value [d] (µg/L)
1,2,4-Trimethylbenzene [e]	2	SB001	1,900 [e]	1.0 [e]	24	12
1,3,5-Trimethylbenzene [e]	0.6	SB001	1,900 [e]	1.0 [e]	25	12
4-Methyl-2-Pentanone	0.9	SB006	NA	NA	NA	NA
Benzene	0.5	SB001 & SB003	1,900	1.0	5.0 [f]	**0.34**
Bromodichloromethane	1	SB001	310	NA	2.1	**0.18**
Carbon Disulfide	0.3	SB022	NA	NA	560	1,000
Chlorodibromomethane [e]	0.9	SB001	1,900 [e]	1.0 [e]	3.2	0.18
Chloroform	1	SB001	1,200	NA	80	6.2
1,1-DCE	1	MW-09	27,000	6.0	190	340
1,2-DCA	0.4	MW-09	510	0.5	5.0 [f]	**0.12**
1,2-DCE –cis	7	SB024	20,000	**6.0**	210	61
1,2-DCE –trans	4	SB024	20,000	10	180	120
Ethylbenzene	1	SB001 & SB003	52,000	680	700	2.9
MTBE [g]	0.9	SB013	48,000	5	120,000	6.2
Naphthalene	0.5	SB011	5,400	NA	150	NA
P-Isopropyltoluene [h]	0.6	SB001	530,000 [h]	150 [h]	NA	120
PCE	100	MW-10	520	**5.0**	**5.0** [f]	**0.66**
TCE	38	SB024	2,100	**5.0**	**5.0** [f]	**0.028**
Toluene	9	SB001	530,000	150	1500	120
M,p-Xylenes	6	SB001	160,000	1750	22,000	210

TABLE 7: COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS IN GROUNDWATER WITH SCREENING LEVELS FOR PROTECTION OF HUMAN HEALTH (Continued)

Draft, Solid Waste Management Units 2, 5, 7, and 18 Feasibility Study
Naval Weapons Station Seal Beach Detachment Concord

Notes:	bold = maximum concentration is greater than screening value
a	San Francisco Regional Water Quality Control Board. “Risk-Based Screening Levels for Impacted Soil and Groundwater.” July 2003. Values are for fine-grained soils and residential land use.
b	California Department of Health Services, “Drinking Water Standards, Primary Maximum Contaminant Levels (MCLs) and Lead and Copper Action Levels,” February 19, 2002 (CDHS website).
c	U.S. Environmental Protection Agency (EPA). “OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils.” November 29. Cited values are from Table 2b for $1x10^{-6}$ risk.
d	EPA, Region IX, “Preliminary Remedial Goals,” October 2002. California-modified PRGs are listed where available.
e	Benzene used as surrogate for residential screen and MCL criteria.
f	OSWER guidance default value is the federal MCL when the MCL is higher than that calculated using the indoor air model.
g	The MCL criteria listed for MTBE is the secondary MCL, which is lower than the primary MCL of 13 µg/L.
h	Toluene used as surrogate for residential screen and MCL criteria.

DCA	Dichloroethane
DCE	Dichloroethene
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NA	None available
ND	Not detected
PCE	Tetrachloroethene
PRG	Preliminary remedial goal
TCE	Trichloroethene

TABLE 8: COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS IN GROUNDWATER WITH SCREENING LEVELS FOR PROTECTION OF FISH AND AQUATIC INVERTEBRATES

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Analyte	Maximum Detection 2002 Sampling Event (µg/L)	Lowest Aquatic Life Protection [a] (µg/L)	Basis [a]	Tier II Secondary Acute Value (µg/L) [b]	Tier II Secondary Chronic Value (µg/L) [b]	Lowest Chronic Value (for all Organisms) (µg/L) [c]
1,2,4-Trimethylbenzene (4)	2	46	NA	NA	NA	NA
1,3,5-Trimethylbenzene (4)	0.6	46	U.S. EPA Ecotox Chronic FW	NA	NA	525,000
4-Methyl-2-Pentanone	0.9	NA	NA	2,200	170	77,400
Benzene	0.5	46	U.S. EPA Ecotox Chronic FW	2,300	130	525,000
Bromodichloromethane	1	6,400	U.S. EPA SW Chronic LOEL	NA	NA	NA
Carbon Disulfide	0.3	NA	NA	17	1	244
Chlorodibromomethane (5)	0.9	6,400	U.S. EPA SW Chronic LOEL	NA	NA	NA
Chloroform	1	28	U.S. DOE FW Chronic PRG	NA	NA	1,240
1,1-Dichloroethene (DCE)	1	25	U.S. DOE FW Chronic PRG	450	25	<2800
1,2-Dichloroethane (DCA)	0.4	910	U.S. DOE FW Chronic PRG	8,800	910	15,200
1,2-Dichloroethene -cis	7	590	U.S. DOE FW Chronic PRG	NA	NA	NA
1,2-Dichloroethene -trans	4	590	U.S. DOE FW Chronic PRG	NA	NA	NA
Ethylbenzene	1	290	U.S. EPA Ecotox Chronic FW	130	7	<440
Methyl tertiary-butyl ether(6)	0.9	NA	NA	NA	NA	NA
Naphthalene(7)	0.5	24	U.S. EPA Ecotox Chronic FW	190	12	620
P-isopropyltoluene (8)	0.6	130	U.S. EPA Ecotox Chronic FW	120	10	1,269
Tert- Butylbenzene (4)	0.4	46	U.S. EPA Ecotox Chronic FW	2,300	130	NA
Tetrachloroethene (PCE)	100	120	U.S. EPA Ecotox Chronic FW	830	98	750
Toluene	9	130	U.S. EPA Ecotox Chronic FW	120	10	1,269
Trichloroethene (TCE)	38	120	U.S. EPA Ecotox Chronic FW	440	47	7,257
M,p-Xylenes	6	13	U.S. DOE FW Chronic PRG	230	13	62,308

TABLE 8: COMPARISON OF MAXIMUM DETECTED CONCENTRATIONS IN GROUNDWATER WITH SCREENING LEVELS FOR PROTECTION OF FISH AND AQUATIC INVERTEBRATES (Continued)

Draft, Solid Waste Management Units 2, 5, 7, and 18 Feasibility Study
Naval Weapons Station Seal Beach Detachment Concord

Notes:

a	San Francisco Regional Water Quality Control Board. "Risk-Based Screening Levels for Impacted Soil and Groundwater." December 2001. Aquatic Life Protection: Addresses potential impact on freshwater or marine aquatic life. Screening levels are lowest of marine and freshwater criteria.
b	U.S. Environmental Protection Agency. 1993. "Great Lakes Water Quality Initiative Criteria Documents for Protection of Aquatic Life in Ambient Water." PB93-154646. National Technical Information Service. Springfield, Virginia.
c	Suter, G. W. II, and C. L. Tsao. 1996. Toxicological Benchmarks for Screening of Potential Contaminants of Concern for Effects on Aquatic Biota on Oak Ridge Reservation: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 104pp, ES/ER/TM-96/R2

<	Less than
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
MCL	Maximum contaminant level
µg/L	Micrograms per liter
NA	Not available
SWMU	Solid Waste Management Unit

U.S. DOE FW Chronic PRG	DOE Chronic Freshwater Preliminary Remediation Goal for Ecological Concerns
U.S. EPA Ecotox Chronic FW	EPA Chronic Freshwater Ecotoxicity Value
U.S. EPA SW Chronic LOAEL	EPA Chronic Surface Water Lowest Observed Effects Level

TABLE 9: CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR GROUNDWATER

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Requirement	Prerequisite	Citation	ARAR Determination	Comments
Cal/EPA Department of Toxic Substances Control				
State MCLs	Groundwater that is a source of drinking water	CCR Title 22 64444	Relevant and Appropriate	Like federal MCLs, these tap water standards relevant and appropriate

Notes:

ARAR Applicable or relevant and appropriate requirement
CCR California Code of Regulations
MCL Maximum contaminant level

TABLE 10: ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR GROUNDWATER
Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Resource Conservation and Recovery Act (Title 42 USC, Chapter 82, 6901 through 6991[i])					
On-site waste generation	Definition of RCRA hazardous waste	Soil and water	CCR Title 22 66261.10(a) and 66262.11	Applicable	The requirements of Title 22 CCR, Division 4.5, Chapter 14 are applicable for determining whether material generated as a result of the remedial alternatives contains hazardous waste. These requirements may be relevant and appropriate to material that is similar or identical to RCRA hazardous waste or non-RCRA hazardous waste.
Hazardous waste accumulation	On-site hazardous waste accumulation is allowed for up to 90 days as long as the waste is stored in containers or tanks, is on drip pads or inside buildings, and is labeled and dated.	Accumulate hazardous waste	CCR Title 22 66262.34	Applicable	These requirements are applicable if hazardous waste is generated and accumulated on site before transport.
Pre-transport requirements	Hazardous waste must be packaged in accordance with DOT regulations for transporting	Any operation where hazardous waste is generated	CCR Title 22 66262.30	Applicable	These requirements are applicable if hazardous waste is to be transported.
	Hazardous waste must be labeled in accordance with DOT regulations for transporting	Any operation where hazardous waste is generated	CCR Title 22 66262.31	Applicable	These requirements are applicable if hazardous waste is to be transported.
	Provides requirements for marking hazardous waste for transporting.	Any operation where hazardous waste is generated	CCR Title 22 66262.32	Applicable	These requirements are applicable if hazardous waste is to be transported.

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Resource Conservation and Recovery Act (Title 42 USC, Chapter 82, 6901 through 6991[i]) (Continued)					
Pre-transport requirements	A generator must ensure that the transport vehicle is correctly placarded prior to transport of hazardous waste.	Any operation where hazardous waste is generated	CCR Title 22 66262.33	Applicable	These requirements are applicable if hazardous waste is to be transported.
	A manifest must be prepared for transport of hazardous waste off site.	Any operation where hazardous waste is generated	CCR Title 22 66262.20-66262.23	Applicable	These requirements are applicable if hazardous waste is to be transported.
Safe Drinking Water Act (42 USC 300f et seq.)					
Underground injection	The UIC program prohibits injection activities that allow movement of contaminants into underground sources of drinking water that may result in violations of MCLs or adversely affect health.	An approved UIC program is required in states listed under SDWA Section 1422. Class I wells and Class IV wells are the relevant classifications for CERCLA sites. Class I wells are used to inject hazardous waste beneath the lowermost formation that contains a USDW within 0.25 mile of the well.	40 CFR 144.12, excluding the reporting requirements in 144.12(b) and 144.12(c)(1)	Relevant and appropriate	These requirements are relevant and appropriate for enhanced bioremediation alternatives.
Federal Hazardous Materials Transportation Law (Title 49 USC 5101 through 5127)					
Transportation of hazardous material	Sets forth requirements for transporting hazardous waste including representations that containers are safe, prohibitions on altering labels and requirements for marking, labeling, and placarding.	Interstate carriers transporting hazardous waste and substance by motor vehicle.	Title 49 CFR 171.2(f), 171.2(g), 172.300, 172.301, 172.302, 172.303, 172.304, 172.312, 172.400, 172.504	Relevant and appropriate	Relevant and appropriate for transporting hazardous materials on site.

TABLE 10: ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR GROUNDWATER (Continued)

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Federal Hazardous Materials Transportation Law (Title 49 USC 5101 through 5127) (Continued)					
Transportation of hazardous material (cont'd)	Definitions of designated waste, nonhazardous waste, and inert waste		CCR Title 22 20210 and 20220	Applicable	Potential ARAR for classifying waste.

Notes:

ARAR	Applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
UIC	Underground injection control
DOT	U.S. Department of Transportation
HRC	Hydrogen release compound
MCL	Maximum contaminant level
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
TBC	To be considered
U.S.C.	United States Code
USDW	Underground Source of Drinking Water

TABLE 11: PRELIMINARY SCREENING OF SOIL AND GROUNDWATER TREATMENT TECHNOLOGIES

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

General Response Action	Technology Group	Treatment Technology	Description	Evaluation Result [a,b]
No Action	No Action	No Action	No remediation, control, or monitoring actions would be taken at the site. The site would be left as it is.	Retained: required to be evaluated under the NCP and CERCLA as amended as a baseline for comparison with other remedial alternatives.
Land Use Controls	Governmental Controls	Zoning Restrictions	A common land use restriction specifying allowed land uses for certain areas. Zoning can be used to prohibit activities that could disturb a certain aspect of a remedy or to control certain exposures not otherwise protected under a remedy.	Retained.
		Groundwater Use Restrictions	Restrictions directed at limiting or prohibiting certain uses of groundwater, for example, the use of groundwater as a drinking water source and prohibitions on well drilling.	Retained.
	Proprietary Controls	Easements	A property right conveyed by a landowner to another party, which gives the second party rights to the landowner's land. For example: affirmative easement – access by a nonlandowner to a property to conduct inspection or monitoring and negative easement – prohibit well-drilling on the property by the landowner.	Retained: necessary component of LUCs to allow property access for long-term monitoring, and readily implementable.
		Covenants	A covenant is an agreement between a landowner to another made in connection with a conveyance of property to use or refrain from using a property in a certain manner (for example, a covenant not to dig on a certain portion of the property).	Retained: effective to ensure that the property would not be used in a manner that compromises the restrictions and is readily implementable.
	Enforcement and permit tools with LUC components	Administrative Orders	An order directly restricting the use of property by a named party.	Eliminated: zoning and groundwater use restrictions would be able to serve the objectives.

TABLE 11: PRELIMINARY SCREENING OF SOIL AND GROUNDWATER TREATMENT TECHNOLOGIES (Continued)
Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

General Response Action	Technology Group	Treatment Technology	Description	Evaluation Result [a,b]
Land Use Controls	Informational Tools	Deed Notice	Commonly refers to a non-enforceable, purely informational document filed in public land records that alerts anyone searching the records to important information about the property.	Retained: complements other LUC components and can be used to require installation of vapor barrier systems before new buildings are built.
Engineering Controls	Containment Systems	Vapor Barrier	Vapor barriers are a passive approach typically employed during construction. Vapor barrier construction consists of installing the vapor barrier (6-mil polyethylene or equivalent) sealing plumbing penetrations, mixing of floor slab concrete with superplasticizers, reinforcing of slab at reentrant corners, and proper slab curing and loading.	Eliminated for existing buildings because of technical impracticability of installation. Retained as a potential LUC requirement for future buildings.
		Sub-slab Depressurization	This approach is active, and uses a depressurization fan to lower the pressure below the slab. This negative pressure creates a sink for VOCs beneath the building; the vapors are collected using the fan in perforated piping in the slab. The fan extracts air from the below the slab and diverts it to ambient air.	Retained as a potentially effective control for future buildings.
Soil Active Remediation	Excavation and Off-Site Disposal	Excavation and Disposal at an Off-site Landfill	Physical removal of contaminated soil in the shallow subsurface using heavy equipment. Transport and dispose of soils without treatment to a permitted landfill.	Eliminated: Excavation under Building IA-12 is not implementable.
	In-situ Treatment	Soil Vapor Extraction	Vacuum is applied through extraction wells to create a pressure/concentration gradient that induces gas-phase volatile compounds to be removed from soil through extraction wells.	Retained: effective technology for VOCs in source area.
Monitored Natural Attenuation	Monitored Natural Attenuation	Monitored Natural Attenuation	Uses natural attenuation processes such as biodegradation, volatilization, and physical/chemical processes to remediate contamination, in conjunction with data collection, long-term monitoring, and modeling	Eliminated: low cost but time frame is 250 years.

TABLE 11: PRELIMINARY SCREENING OF SOIL AND GROUNDWATER TREATMENT TECHNOLOGIES (Continued)
Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

General Response Action	Technology Group	Treatment Technology	Description	Evaluation Result [a,b]
Groundwater Active Remediation	Ex-situ Treatment	Pump & Treat by Air Stripping	Air stripping is a full-scale technology that partitions volatile organic compounds from groundwater by greatly increasing the surface area of the contaminated water exposed to air. Types of aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.	Retained: considered a presumptive remedy by EPA[c] but long-term timeframe and high cost.
		Pump & Treat by Chemical/UV Oxidation	Organic compounds are destroyed by adding strong oxidizers and irradiation with UV light. Oxidation reactions are achieved by the synergistic action of UV light with ozone or hydrogen peroxide.	Eliminated: long-term timeframe and high cost.
		Pump & Treat by Carbon Adsorption	Groundwater is pumped through a series of canisters or columns containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required.	Eliminated: long-term timeframe and high cost.
	In-situ Treatment	Air Sparging with Soil Vapor Extraction	For air sparging, air is injected through a contaminated aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants by volatilization. The air that contains stripped contaminants is recovered by soil vapor extraction in the vadose zone.	Retained: effective technology for VOCs in source area. Effectiveness may be limited for the low concentrations that are found in most of the plume.
		Biosparging	Biosparging is similar to air sparging except that air is injected at a much lower flow rate and vapor collection is not needed. The application of this technology relies on adequate distribution of air through the subsurface.	Eliminated: limited effectiveness for treatment of TCE and PCE.
		In Situ Chemical Oxidation	Chemical oxidants are injected into the aquifer. Oxidation chemically converts hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, or inert.	Eliminated: limited effectiveness and high cost for treatment of entire plume.

TABLE 11: PRELIMINARY SCREENING OF SOIL AND GROUNDWATER TREATMENT TECHNOLOGIES (Continued)
Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

General Response Action	Technology Group	Treatment Technology	Description	Evaluation Result [a,b]
Groundwater Active Remediation	In-situ Treatment	Thermal Treatment (Steam Flushing)	Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone, where they are removed by vacuum extraction and then treated.	Eliminated: low effectiveness and high cost
		Passive Treatment Wall	A permeable reaction wall is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. These barriers allow water to pass while prohibiting movement of contaminants by employing such agents as zero-valent metals, chelators (ligands selected for their specificity for a given metal), sorbents, and microbes.	Eliminated: would require long-term monitoring and maintenance.
		Enhanced In-situ Bioremediation using HRC	HRC is a proprietary polyacetate ester specially formulated for slow release of lactic acid on hydration. HRC is applied to the subsurface via push-point injection or within dedicated wells and is left in place to stimulate rapid contaminant degradation.	Retained: HRC is effective for halogenated VOCs. Medium-term timeframe and medium cost.
		Enhanced In-situ Bioremediation using ORC	ORC is a patented formulation of magnesium peroxide that produces a slow and sustained release of molecular oxygen when in contact with soil moisture or groundwater. ORC is applied to the subsurface via push-point injection or within dedicated wells and is left in place to stimulate rapid contaminant degradation.	Eliminated: ORC is effective for vinyl chloride and 1,2-DCE. Medium-term timeframe and medium cost.

Notes:

a Cost::

Low	Less than $3.00/1,000 gallons
Medium	$3.00-$10.00/1,000 gallons
High	More than $10/1,000 gallons

b Timeframe:

Short Term	Less than 3 years of implementation
Medium Term	3 to 10 years of implementation
Long Term	More than 10 years of implementation

c U.S. Environmental Protection Agency (EPA). 1996. Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites. Final Guidance. Directive 9283.1-12, EPA 540/R-96/023. Office of Solid Waste and Emergency Response. Washington, D.C. October.

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
DCE Dichloroethene
EC Engineering Controls
EPA U.S. Environmental Protection Agency
HRC Hydrogen releasing compound
LUC Land-use Control
NCP National Oil and Hazardous Substances Pollution Contingency Plan
ORC Oxygen-releasing compounds
VOC Volatile organic compounds
UV Ultraviolet

TABLE 12: SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER TREATMENT TECHNOLOGIES RETAINED FROM THE PRELIMINARY SCREENING

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Evaluation Criteria	Air Sparging with Soil Vapor Extraction	Enhanced Bioremediation Using HRC Throughout Plume	Enhanced Bioremediation Using HRC in Main Portion of Plume	Pump and Treat with Air Stripping
Effectiveness	Well known with proven success. May be limited by low permeability. Expected remediation time is 2 years, followed by 2 years of groundwater monitoring.	Proven success for VOC plumes. However, treatability study should be conducted. Expected remediation time is 3 years, followed by 2 years of groundwater monitoring.	Proven success for VOC plumes. However, treatability study should be conducted. Expected remediation time is 20 years.	EPA presumptive remedy. May be limited by low permeability. Expected remediation time is at least 30 years.
Implementability	Likely to be implementable. Air sparging should be tested at the pilot scale before full-scale implementation. Surface structures in source area may restrict site access in limited area.	Implementable, but a treatability study should be conducted. Treatment agents are not hazardous. Access to site not restricted because no surface structures required.	Implementable, but a treatability study should be conducted. Treatment agents are not hazardous. Access to site not restricted because no surface structures required.	Likely to be implementable, but pumping tests should be conducted to evaluate effects of pumping on aquifer.
Cost[a]	$XX million			$XX.X million

Notes:

a Cost estimates are for reducing COC concentrations to below domestic use remedial goals.

HRC Hydrogen Releasiing Compound

TABLE 13: SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Effectiveness Criteria	Alternative 1: No Action	Alternative 2: Air Sparging with Soil Vapor Extraction	Alternative 3A: Enhanced Bioremediation Throughout Plume	Alternative 3B: Enhanced Bioremediation in Main Portion of Plume	Alternative 4: Pump and Treat with Air Stripping
1. Overall Protection of Human Health and the Environment[a]	No protection of domestic use pathway with unrestricted reuse. No protection of vapor intrusion pathway for potential future residential use.	Protective of human health.	Protective of human health.	Protective of human health.	Protective of human health.
2. Compliance with ARARs[a]	Does not meet ARARs.	Meets ARARs.	Meets ARARs.	Meets ARARs.	Meets ARARs.
3. Long-term Effectiveness and Permanence[b]	Does not provide long-term effectiveness.	Treatment reduces concentrations to below remedial goals.	Treatment reduces concentrations to below remedial goals.	Treatment reduces concentrations to below remedial goals in the main portion of the plume. Natural attenuation and effects of treatment eventually reduce concentrations to below remedial goals in the remainder of the plume. LUCs prevent exposure until concentrations in groundwater reach remedial goals.	Treatment eventually reduces concentrations to below remedial goals. LUCs prevent exposure until concentrations in groundwater reach remedial goals.
4. Reduction in Toxicity, Mobility, and Volume through Treatment[b]	Would not reduce toxicity, mobility, or volume of contamination through treatment.	Would reduce toxicity, mobility, or volume of contamination through treatment.	Would reduce toxicity, mobility, or volume of contamination through treatment.	Would reduce toxicity, mobility, or volume of contamination through treatment in the main portion of the plume.	Would reduce toxicity, mobility, or volume of contamination through treatment.
5. Short-term Effectiveness[b]	No short-term risk because no active remediation activities are proposed.	No short-term risks.	No short-term risks.	No short-term risks.	No short-term risks.
6. Technical Implementability[b]	Readily implementable.	Technically feasible.	Technically feasible.	Technically feasible. May require LUCs.	Technically feasible. May require LUCs.
7. Cost[b]	No cost.	$ 4.4 million	$ 2.6 million	$ 1.5 million	$ 13 million
8. State Acceptance[c]	***	***	***	***	***
9. Community Acceptance[c]	***	***	***	***	***

Notes:

a The first two criteria are threshold criteria. All remedial alternatives must meet the threshold criteria. No ecological risks were identified for SWMUs 2, 5, 7, and 18 in the RI (Tetra Tech 2004).
b These criteria are evaluation criteria used to select the alternative.
c The last two criteria are modifying criteria that reflect the state's and community's alternative preference.

*** Formal approval will be issued after the proposed plan is prepared.
ARAR Applicable or relevant and appropriate requirement
EC Engineering controls
HRC Hydrogen releasing compound
LUC Land-use controls
M Million
MCL Maximum contaminant level

APPENDIX A
MODELING TO EVALUATE MONITORED NATURAL ATTENUATION AS A REMEDIAL ALTERNATIVE

1.0 INTRODUCTION

This appendix presents the results of groundwater modeling conducted to estimate the time required for natural attenuation processes to reduce the concentrations of volatile organic compounds (VOC) in groundwater at Solid Waste Management Units (SWMU) 2, 5, 7, and 18 at Naval Weapons Station Seal Beach, Detachment Concord (NWSSBD Concord) to concentrations below remedial goals. As discussed in Section 7.1.3 of the feasibility study (FS), the remedial goals are the California maximum contaminant levels (MCL) for drinking water. BIOCHLOR Version 2.2, a screening model developed by the U.S. Environmental Protection Agency (Aziz and others 2002), was used to simulate natural attenuation processes at SWMUs 2, 5, 7, and 18.

2.0 DESCRIPTION OF GROUNDWATER CONTAMINATION

The site geology and hydrogeology are described in Section 2.6 of the FS. Tetrachloroethene (PCE), trichloroethene (TCE), and cis-1,2-dichloroethene (DCE) have been detected in groundwater at concentrations that exceed MCLs. The nature and extent of VOC contamination in groundwater is discussed in Section 3.2 of the FS. PCE has been detected at the highest concentrations; the maximum concentration of PCE detected at the site is 100 micrograms per liter (μg/L). Vinyl chloride has not been detected at the site, suggesting that biodegradation of chlorinated ethenes is not a significant factor at the site. Sufficient data are not available to evaluate trends in the concentrations of VOCs over time. However, VOC concentrations detected in 2002 in samples from well MW-10 were higher were detected during three sampling events in 1997. Well MW-10 is within the central portion of the plume, and samples from the well contained the highest concentrations of VOCs at the site. Therefore, the plume does not appear to be stable or decreasing in size.

A former underground storage tank (UST) located near Building IA-12 (see Section 2.3.2.2 in the FS) was the source of the VOC plume at SWMUs 2, 5, 7, and 18. The 6,000-gallon UST was installed in about 1980 and was removed on November 4, 1993 (Ramcon 1994). Based on the assumption that the former waste oil UST was the source of VOCs at the site, VOC discharges began as early as approximately 1980. The most recent data for groundwater were collected during 2002. Therefore, the 2002 data represent the extent of the VOC plume over a 22-year period of expansion (approximately 1980 to 2002). A model simulation of 22 years was therefore used to calibrate the model to field data.

3.0 MODELING INPUT PARAMETERS

The hydrogeologic and chemical parameters used in the model are based on field data from the site, where available. Table A-1 presents the values used in the model and describes the source or rationale for each parameter. The parameters are estimated based on typical values for similar sites where site-specific data were not available.

Based on aquifer test results, a hydraulic conductivity of 4 feet per day was originally used as input to the model, resulting in a seepage velocity of 29 feet per year. Using this low seepage velocity, the extent of the plume simulated by the model was much smaller than the current plume. The hydraulic conductivity was therefore increased to 12 feet per day to calibrate the model results to more closely fit the current extent of the plume.

The BIOCHLOR model assumes that the aquifer is homogeneous and isotropic and that groundwater flow is horizontal, unidirectional, and steady state.

4.0 MODELING RESULTS

The model was sensitive to the rate of source decay in predicting the time required to reach MCLs. Source decay can be estimated based on trends in concentration over time. However, sufficient data are not available at SWMUs 2, 5, 7, and 18 to estimate source decay. Therefore, the model was run using a continuous source. For comparison, the model was also run using a source decay coefficient to simulate degradation of VOCs over the over the long simulation periods needed to reach MCLs. The continuous-source scenario assumes that the concentration at the source remains constant with no decay over time (Runs 1 through 5 in Table A-2). Runs 6 through 9 used a source decay coefficient of 0.02 to simulate possible degradation of VOCs in the source area

Model results for PCE are summarized on Table A-2. MCLs were not achieved at the site within 500 years in simulations using a continuous source, and concentrations increased over time within the plume. MCLs were achieved in 250 years in simulations using the source decay coefficient of 0.02. Based on these model results, VOC concentrations will not reach MCLs at the site through natural attenuation for more than 250 years.

Vinyl chloride has not been detected at the site. Therefore, no biotransformation was assumed for the model. The model requires that minimum decay coefficients be input, but the output shows two sets of results that represent no degradation and biotransformation (see Attachment A-1). The results shown on Table A-2 represent the simulation results for no degradation.

5.0 CONCLUSION

Model simulations using BIOCHLOR indicate that the time required for VOC concentrations to reach MCLs by natural attenuation processes at SWMUs 2, 5, 7, and 18 exceeds 250 years. Therefore, monitored natural attenuation is not a viable remedial alternative for the site.

REFERENCES

Aziz, C.E., Newell, C.J., Gonzalez, J.R., Hass, P, Lement, T.P., and Sun, Y. 2002. "BIOCHLOR – Natural Attenuation Decision Support System (Version 2.2)." Groundwater Services, Inc., Houston, Texas, for the Air Force Center for Environmental Excellence.

Ramcon. 1994. "Underground Storage Tank Closure Report, IA-12, Concord Naval Weapons Station, Concord, California." March 8.

TABLES

TABLE A-1: BIOCHLOR INPUT PARAMETERS

Internal Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

Input Parameter	Values Used	Source or Rationale
Advection		
Seepage Velocity	86.9 feet/year	Calculated by model from other advection parameters
Hydraulic Conductivity	4.3E-03 centimeters per second	Original value was based on results from slug tests at site. Final value used was based on best-fit calibration of the model.
Hydraulic Gradient	0.005 feet/feet	Site-specific data
Effective Porosity	0.28	Estimated value
Dispersion		
Alpha x	0.1x L, feet	Estimated from plume length L, feet
Adsorption		
Soil Bulk Density	1.6 kg/L	Estimated value
Fraction Organic Carbon	0.003	Based on site-specific data
Partition Coefficients	Variable	Typical values suggested in user's manual
Biotransformation		
First Order Decay	No decay	Vinyl chloride was not detected at the site. The best-fit calibration fits the no degradation curve.
Source Data		
Source Thickness	15 feet	Estimated based on depth of groundwater samples collected at site.
Source Width	30 feet	Based on site-specific data
PCE Concentration	0.5 mg/L	Estimated from concentrations near the source area.
TCE Concentration	0.15 mg/L	Estimated from concentrations near the source area.
DCE Concentration	0.025 mg/L	Estimated from concentrations near the source area.
Vinyl Chloride Concentration	0	Vinyl chloride has not been detected at the site.
Ethene Concentration	0	Assumed not to be present based on absence of vinyl chloride.
Source Decay	Continuous source and source decay of 0.02	Sensitive parameter for time of remediation. Model was run using both continuous source and source decay.

Notes:

DCE	Dichloroethene
kg/L	Kilograms per liter
mg/kg	Milligrams per liter
PCE	Tetrachloroethene
TCE	Trichloroethene

TABLE A-2: MODELING RESULTS

Internal Draft Feasibility Study, Solid Waste Management Units 2, 5, 7, and 18
Naval Weapons Station Seal Beach Detachment Concord

INPUT PARAMETERS			MODEL OUTPUT		
Model Run	**Simulation Time (Years)**	**Source Decay (1/year)**	**Maximum PCE Concentration in Plume[a] (μg/L)**	**Plume Length[b] (Feet)**	**Achieved Remedial Goals?**
1	22	No decay	500	1,200	No
2	50	No decay	500	2,400	No
3	100	No decay	500	4,000	No
4	250	No decay	500	8,000	No
5	500	No decay	500	15,000	No
6	22	0.02	332	1,200	No
7	50	0.02	184	2,400	No
8	100	0.02	68	3,500	No
9	250	0.02	4	8,000	Yes

Notes:

a The maximum concentration of PCE represents the highest concentration of PCE in the plume, assuming no biotransformation.

b The plume length is defined by the isoconcentration contour of 1 μg/L.

μg/L Micrograms per liter

PCE Tetrachloroethene

ATTACHMENT A-1
MODEL SIMULATIONS

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2

Excel 2000

NWSSBD Concord
SWMU Run 1

Run Name

Data Input Instructions:

115 → 1. Enter value directly....or

or 2. Calculate by filling in gray

0.02 cells. Press Enter, then C

(To restore formulas, hit "Restore Formulas" button)

Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	86.9	(ft/yr)
or			
Hydraulic Conductivity	K	4.2E-03	(cm/sec)
Hydraulic Gradient	i	0.005	(ft/ft)
Effective Porosity	n	0.25	(-)

2. DISPERSION

Alpha x*	140	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)		
FractionOrganicCarbon, foc	3.0E-3	(-)		
Partition Coefficient	Koc			
PCE	426	(L/kg)	9.18	(-)
TCE	130	(L/kg)	3.50	(-)
DCE	125	(L/kg)	3.40	(-)
VC	30	(L/kg)	1.57	(-)
ETH	302	(L/kg)	6.80	(-)

Common R (used in model)* = 3.50

4. BIOTRANSFORMATION **-1st Order Decay Coefficient***

Zone 1

	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.070		0.79
TCE → DCE	0.050		0.74
DCE → VC	0.180		0.64
VC → ETH	0.120		0.45

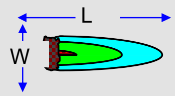
Zone 2

	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	22	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	3000	(ft)
Zone 1 Length*	3000	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Continuous Single Planar

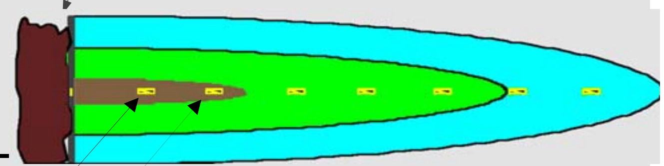
Source Options

Source Thickness in Sat. Zone* 15 (ft)

Width* (ft) Y1: 30

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.5	0
TCE	.15	0
DCE	.025	0
VC		0
ETH		0

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	.086	.047	.1	.043	.033	.005	.006	.003			
TCE Conc. (mg/L)	.038	.019	.029	.015	.011	.0	.0	.0			
DCE Conc. (mg/L)	.007	.006	.005	.003	.002	.0	.0	.0			
VC Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
ETH Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
Distance from Source (ft)	55	125	240	290	540	820	970	1350			
Date Data Collected	2002										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE **RUN ARRAY** ***Help*** Restore Formulas RESET ***SEE OUTPUT*** Paste Example

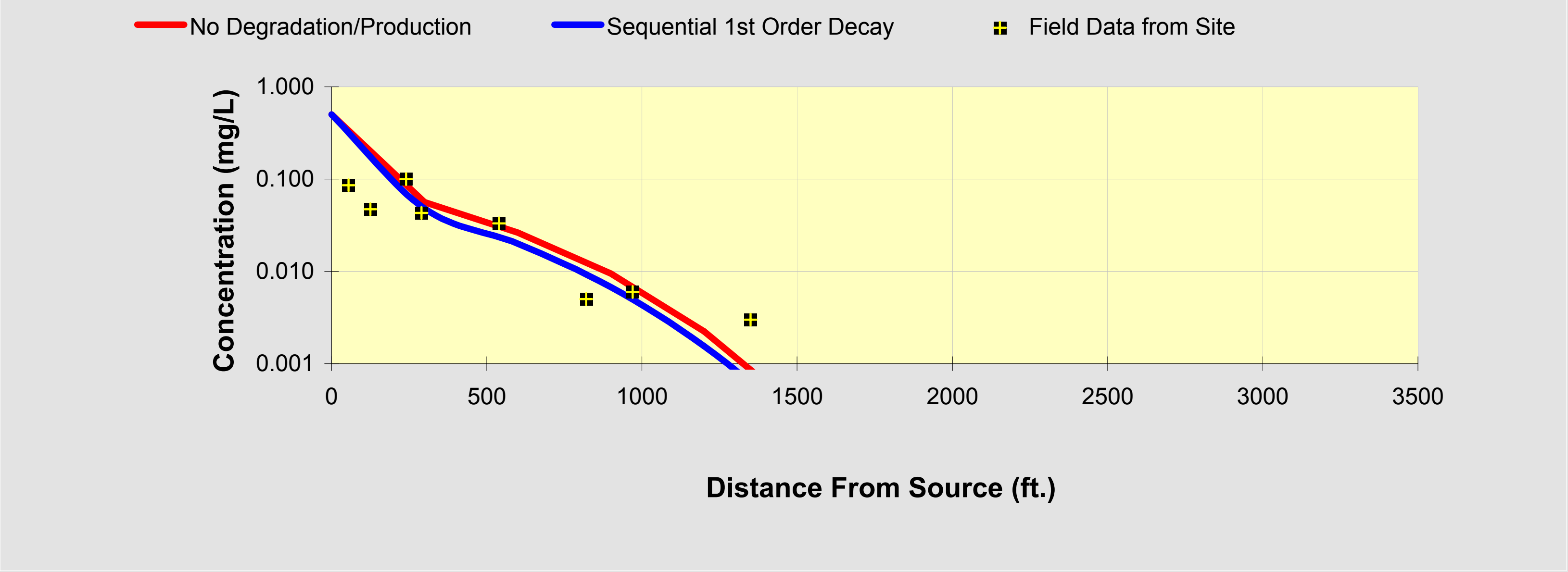
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

PCE	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
No Degradation	0.500	0.056	0.026	0.009	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.5000	0.048	0.020	0.007	0.002	0.000	0.000	0.000	0.000	0.000	0.000

Monitoring Well Locations (ft)

	55	125	240	290	540	820	970	1350			
Field Data from Site	0.086	0.047	0.100	0.043	0.033	0.005	0.006	0.003			



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

22.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2

Excel 2000

NWSSBD Concord

SWMU Run 2

Run Name

Data Input Instructions:

115 → 1. Enter value directly....or

or 2. Calculate by filling in gray

0.02 cells. Press Enter, then C

(To restore formulas, hit "Restore Formulas" button)

Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	86.9	(ft/yr)
or			
Hydraulic Conductivity	K	4.2E-03	(cm/sec)
Hydraulic Gradient	i	0.005	(ft/ft)
Effective Porosity	n	0.25	(-)

2. DISPERSION

Alpha x*	140	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)
FractionOrganicCarbon, foc	3.0E-3	(-)

Partition Coefficient	Koc		R	
PCE	426	(L/kg)	9.18	(-)
TCE	130	(L/kg)	3.50	(-)
DCE	125	(L/kg)	3.40	(-)
VC	30	(L/kg)	1.57	(-)
ETH	302	(L/kg)	6.80	(-)

Common R (used in model)* = 3.50

4. BIOTRANSFORMATION **-1st Order Decay Coefficient***

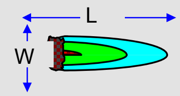
Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.070		0.79
TCE → DCE	0.050		0.74
DCE → VC	0.180		0.64
VC → ETH	0.120		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	50	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	3000	(ft)
Zone 1 Length*	3000	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Continuous Single Planar

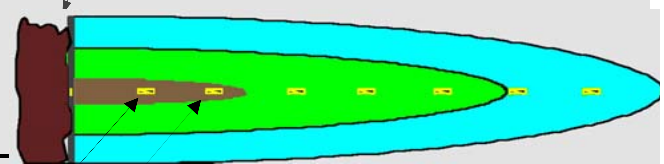
Source Options

Source Thickness in Sat. Zone* 15 (ft)

Width* (ft) Y1: 30

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.5	0
TCE	.15	0
DCE	.025	0
VC		0
ETH		0

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	.086	.047	.1	.043	.033	.005	.006	.003			
TCE Conc. (mg/L)	.038	.019	.029	.015	.011	.0	.0	.0			
DCE Conc. (mg/L)	.007	.006	.005	.003	.002	.0	.0	.0			
VC Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
ETH Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
Distance from Source (ft)	55	125	240	290	540	820	970	1350			
Date Data Collected	2002										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore Formulas

RESET

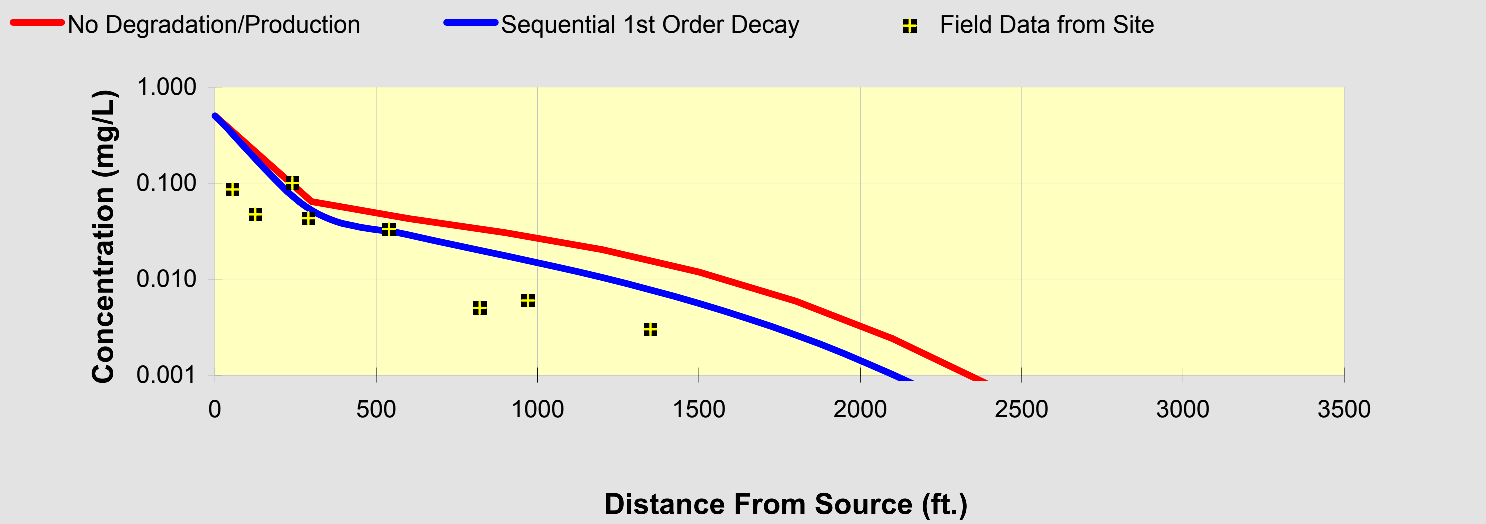
SEE OUTPUT

Paste Example

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

PCE	Distance from Source (ft)										
	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
No Degradation	0.500	0.064	0.043	0.030	0.020	0.012	0.006	0.002	0.001	0.000	0.000
Biotransformation	0.5000	0.052	0.029	0.018	0.010	0.006	0.003	0.001	0.000	0.000	0.000

	Monitoring Well Locations (ft)										
	55	125	240	290	540	820	970	1350			
Field Data from Site	0.086	0.047	0.100	0.043	0.033	0.005	0.006	0.003			



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

50.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2

Excel 2000

NWSSBD Concord
SWMU Run 3

Run Name

Data Input Instructions:

115 → 1. Enter value directly....or

or 2. Calculate by filling in gray

0.02 cells. Press Enter, then C

(To restore formulas, hit "Restore Formulas" button)

Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	86.9	(ft/yr)
or			
Hydraulic Conductivity	K	4.2E-03	(cm/sec)
Hydraulic Gradient	i	0.005	(ft/ft)
Effective Porosity	n	0.25	(-)

2. DISPERSION

Alpha x*	140	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)
FractionOrganicCarbon, foc	3.0E-3	(-)

Partition Coefficient	Koc		R	
PCE	426	(L/kg)	9.18	(-)
TCE	130	(L/kg)	3.50	(-)
DCE	125	(L/kg)	3.40	(-)
VC	30	(L/kg)	1.57	(-)
ETH	302	(L/kg)	6.80	(-)

Common R (used in model)* = 3.50

4. BIOTRANSFORMATION **-1st Order Decay Coefficient***

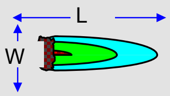
Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.070		0.79
TCE → DCE	0.050		0.74
DCE → VC	0.180		0.64
VC → ETH	0.120		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	100	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	5000	(ft)
Zone 1 Length*	5000	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Continuous Single Planar

Source Options

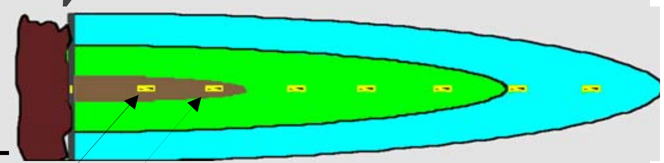
Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

Source Thickness in Sat. Zone* 15 (ft)

Y1

Width* (ft) 30

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.5	0
TCE	.15	0
DCE	.025	0
VC		0
ETH		0



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	.086	.047	.1	.043	.033	.005	.006	.003			
TCE Conc. (mg/L)	.038	.019	.029	.015	.011	.0	.0	.0			
DCE Conc. (mg/L)	.007	.006	.005	.003	.002	.0	.0	.0			
VC Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
ETH Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
Distance from Source (ft)	55	125	240	290	540	820	970	1350			
Date Data Collected	2002										

8. CHOOSE TYPE OF OUTPUT TO SEE:

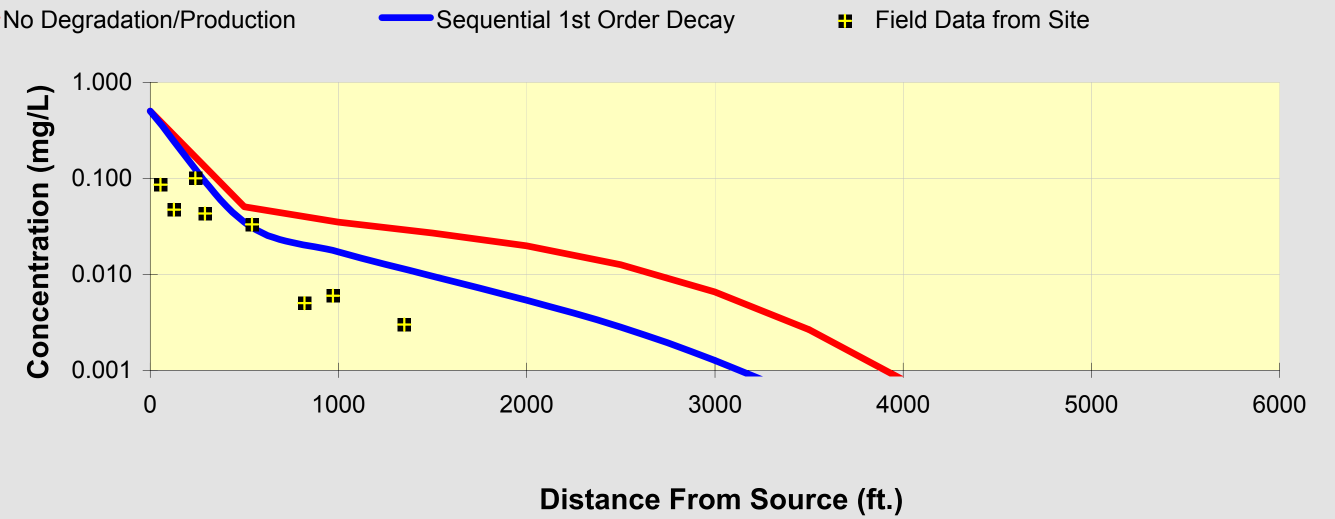
RUN CENTERLINE **RUN ARRAY** ***Help*** Restore Formulas RESET ***SEE OUTPUT*** Paste Example

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

PCE

Distance from Source (ft)	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
No Degradation	0.500	0.050	0.035	0.027	0.020	0.013	0.007	0.003	0.001	0.000	0.000
Biotransformation	0.5000	0.035	0.017	0.010	0.005	0.003	0.001	0.000	0.000	0.000	0.000

Monitoring Well Locations (ft)	55	125	240	290	540	820	970	1350			
Field Data from Site	0.086	0.047	0.100	0.043	0.033	0.005	0.006	0.003			



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

100.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel 2000

NWSSBD Concord
SWMU Run 4
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
or 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	86.9	(ft/yr)
or			
Hydraulic Conductivity	K	4.2E-03	(cm/sec)
Hydraulic Gradient	i	0.005	(ft/ft)
Effective Porosity	n	0.25	(-)

2. DISPERSION

Alpha x*	140	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)
FractionOrganicCarbon, foc	3.0E-3	(-)

Partition Coefficient	Koc		R	
PCE	426	(L/kg)	9.18	(-)
TCE	130	(L/kg)	3.50	(-)
DCE	125	(L/kg)	3.40	(-)
VC	30	(L/kg)	1.57	(-)
ETH	302	(L/kg)	6.80	(-)

Common R (used in model)* = 3.50

4. BIOTRANSFORMATION

-1st Order Decay Coefficient*

Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.070		0.79
TCE → DCE	0.050		0.74
DCE → VC	0.180		0.64
VC → ETH	0.120		0.45

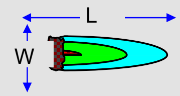
Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	250	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	10000	(ft)
Zone 1 Length*	10000	(ft)
Zone 2 Length*	0	(ft)

Zone 2= L - Zone 1



6. SOURCE DATA

TYPE: Continuous Single Planar

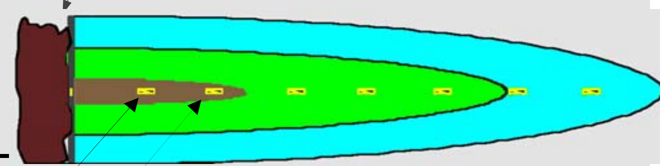
Source Options

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

Source Thickness in Sat. Zone* 15 (ft)

Width* (ft): Y1 = 30

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.5	0
TCE	.15	0
DCE	.025	0
VC		0
ETH		0



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	.086	.047	.1	.043	.033	.005	.006	.003			
TCE Conc. (mg/L)	.038	.019	.029	.015	.011	.0	.0	.0			
DCE Conc. (mg/L)	.007	.006	.005	.003	.002	.0	.0	.0			
VC Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
ETH Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
Distance from Source (ft)	55	125	240	290	540	820	970	1350			
Date Data Collected	2002										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore Formulas

RESET

SEE OUTPUT

Paste Example

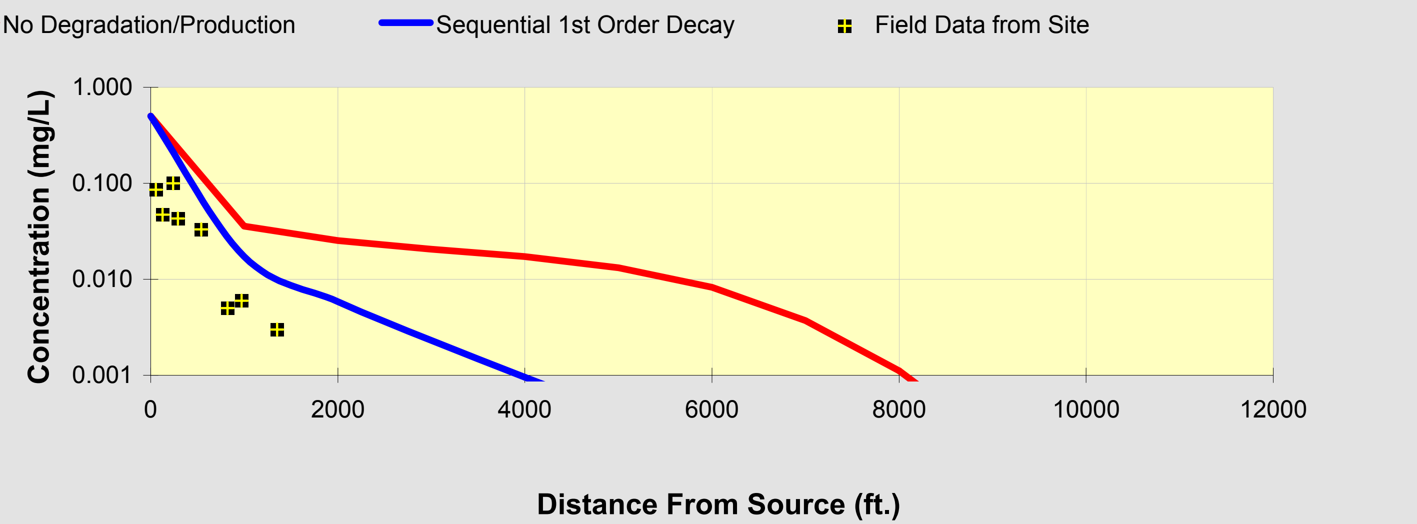
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

PCE	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
No Degradation	0.500	0.036	0.025	0.021	0.017	0.013	0.008	0.004	0.001	0.000	0.000
Biotransformation	0.5000	0.017	0.006	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000

Monitoring Well Locations (ft)

	55	125	240	290	540	820	970	1350			
Field Data from Site	0.086	0.047	0.100	0.043	0.033	0.005	0.006	0.003			



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

250.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support Systen

Version 2.2
Excel 2000

NWSSBD Concord
SWMU Run 5
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
or 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes (selected) / Ethanes

1. ADVECTION

Seepage Velocity*	Vs	86.9	(ft/yr)
or			
Hydraulic Conductivity	K	4.2E-03	(cm/sec)
Hydraulic Gradient	i	0.005	(ft/ft)
Effective Porosity	n	0.25	(-)

2. DISPERSION

Alpha x*	140	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)		
FractionOrganicCarbon, foc	3.0E-3	(-)		
Partition Coefficient	Koc			
PCE	426	(L/kg)	9.18	(-)
TCE	130	(L/kg)	3.50	(-)
DCE	125	(L/kg)	3.40	(-)
VC	30	(L/kg)	1.57	(-)
ETH	302	(L/kg)	6.80	(-)

Common R (used in model)* = 3.50

4. BIOTRANSFORMATION -1st Order Decay Coefficient*

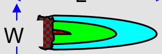
Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.070		0.79
TCE → DCE	0.050		0.74
DCE → VC	0.180		0.64
VC → ETH	0.120		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	500	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	15000	(ft)
Zone 1 Length*	15000	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Continuous Single Planar

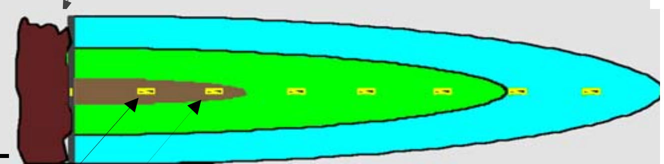
Source Options

Source Thickness in Sat. Zone* 15 (ft)

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

	Y1
Width* (ft)	30

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.5	0
TCE	.15	0
DCE	.025	0
VC		0
ETH		0



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	.086	.047	.1	.043	.033	.005	.006	.003			
TCE Conc. (mg/L)	.038	.019	.029	.015	.011	.0	.0	.0			
DCE Conc. (mg/L)	.007	.006	.005	.003	.002	.0	.0	.0			
VC Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
ETH Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
Distance from Source (ft)	55	125	240	290	540	820	970	1350			
Date Data Collected	2002										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

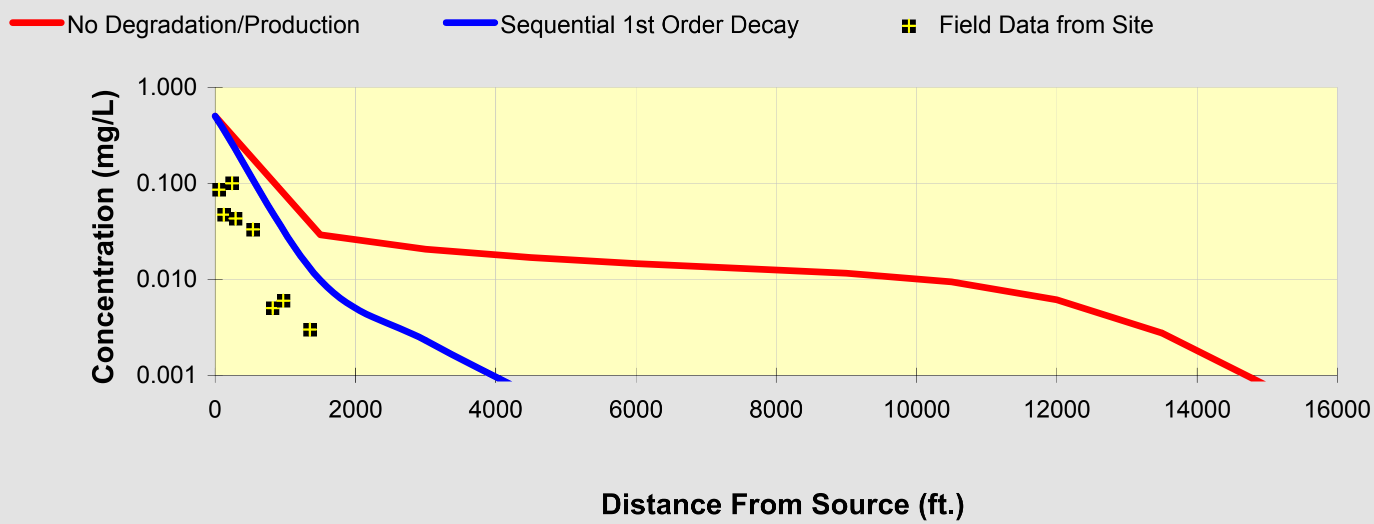
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

PCE	0	1500	3000	4500	6000	7500	9000	10500	12000	13500	15000
No Degradation	0.500	0.029	0.021	0.017	0.015	0.013	0.012	0.009	0.006	0.003	0.001
Biotransformation	0.5000	0.010	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Monitoring Well Locations (ft)

	55	125	240	290	540	820	970	1350			
Field Data from Site	0.086	0.047	0.100	0.043	0.033	0.005	0.006	0.003			



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

500.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support Systen

Version 2.2

Excel 2000

NWSSBD Concord

SWMU Run 6

Run Name

Data Input Instructions:

115 → 1. Enter value directly....or

or 2. Calculate by filling in gray

0.02 cells. Press Enter, then C

(To restore formulas, hit "Restore Formulas" button)

Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	86.9	(ft/yr)
or			
Hydraulic Conductivity	K	4.2E-03	(cm/sec)
Hydraulic Gradient	i	0.005	(ft/ft)
Effective Porosity	n	0.25	(-)

2. DISPERSION

Alpha x*	140	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)
FractionOrganicCarbon, foc	3.0E-3	(-)

Partition Coefficient	Koc		R	
PCE	426	(L/kg)	9.18	(-)
TCE	130	(L/kg)	3.50	(-)
DCE	125	(L/kg)	3.40	(-)
VC	30	(L/kg)	1.57	(-)
ETH	302	(L/kg)	6.80	(-)

Common R (used in model)* = 3.50

4. BIOTRANSFORMATION **-1st Order Decay Coefficient***

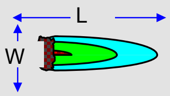
Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.070		0.79
TCE → DCE	0.050		0.74
DCE → VC	0.180		0.64
VC → ETH	0.120		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	22	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	3000	(ft)
Zone 1 Length*	3000	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA TYPE: Decaying Single Planar

Source Options

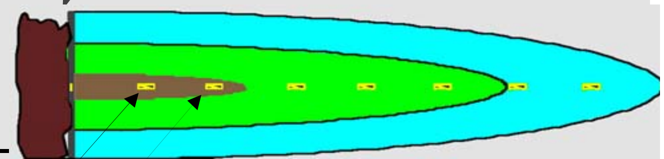
Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

Source Thickness in Sat. Zone* 15 (ft)

Y1

Width* (ft) 30

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.5	0.02
TCE	.15	0.02
DCE	.025	0.02
VC		0.02
ETH		0.02



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	.086	.047	.1	.043	.033	.005	.006	.003			
TCE Conc. (mg/L)	.038	.019	.029	.015	.011	.0	.0	.0			
DCE Conc. (mg/L)	.007	.006	.005	.003	.002	.0	.0	.0			
VC Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
ETH Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
Distance from Source (ft)	55	125	240	290	540	820	970	1350			
Date Data Collected	2002										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

RUN ARRAY

Help

Restore Formulas

RESET

SEE OUTPUT

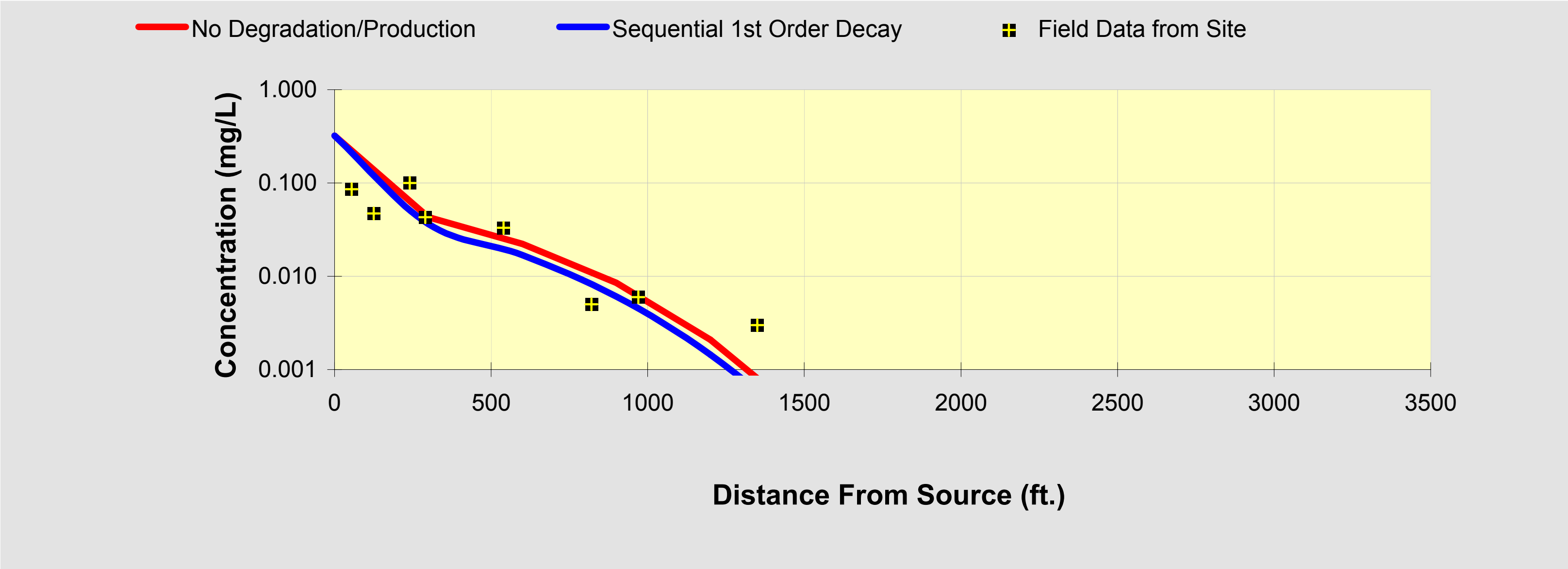
Paste Example

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

PCE

Distance from Source (ft)	0	300	600	900	1200	1500	1800	2100	2400	2700	3000
No Degradation	0.322	0.043	0.022	0.009	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.3220	0.036	0.017	0.006	0.001	0.000	0.000	0.000	0.000	0.000	0.000

Monitoring Well Locations (ft)	55	125	240	290	540	820	970	1350			
Field Data from Site	0.086	0.047	0.100	0.043	0.033	0.005	0.006	0.003			



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

22.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOCHLOR Natural Attenuation Decision Support Systen

Version 2.2

Excel 2000

NWSSBD Concord

SWMU Run 9

Run Name

Data Input Instructions:

115 → 1. Enter value directly....or

or 2. Calculate by filling in gray

0.02 cells. Press Enter, then C

(To restore formulas, hit "Restore Formulas" button)

Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	86.9	(ft/yr)
or			
Hydraulic Conductivity	K	4.2E-03	(cm/sec)
Hydraulic Gradient	i	0.005	(ft/ft)
Effective Porosity	n	0.25	(-)

2. DISPERSION

Alpha x*	140	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-99	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)		
FractionOrganicCarbon, foc	3.0E-3	(-)		
Partition Coefficient	Koc			
PCE	426	(L/kg)	9.18	(-)
TCE	130	(L/kg)	3.50	(-)
DCE	125	(L/kg)	3.40	(-)
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4. BIOTRANSFORMATION

-1st Order Decay Coefficient*

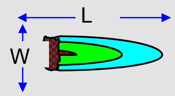
Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.070		0.79
TCE → DCE	0.050		0.74
DCE → VC	0.180		0.64
VC → ETH	0.120		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	250	(yr)
Modeled Area Width*	200	(ft)
Modeled Area Length*	10000	(ft)
Zone 1 Length*	10000	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA

TYPE: Decaying Single Planar

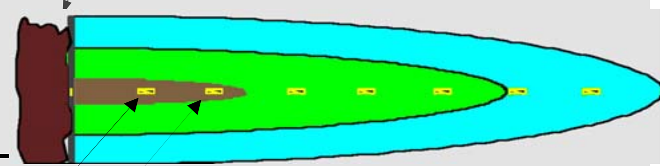
Source Options

Source Thickness in Sat. Zone* 15 (ft)

Width* (ft) Y1: 30

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE	.5	0.02
TCE	.15	0.02
DCE	.025	0.02
VC		0.02
ETH		0.02

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)	.086	.047	.1	.043	.033	.005	.006	.003			
TCE Conc. (mg/L)	.038	.019	.029	.015	.011	.0	.0	.0			
DCE Conc. (mg/L)	.007	.006	.005	.003	.002	.0	.0	.0			
VC Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
ETH Conc. (mg/L)	.0	.0	.0	.0	.0	.0	.0	.0			
Distance from Source (ft)	55	125	240	290	540	820	970	1350			
Date Data Collected	2002										

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

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Help

Restore Formulas

RESET

SEE OUTPUT

Paste Example

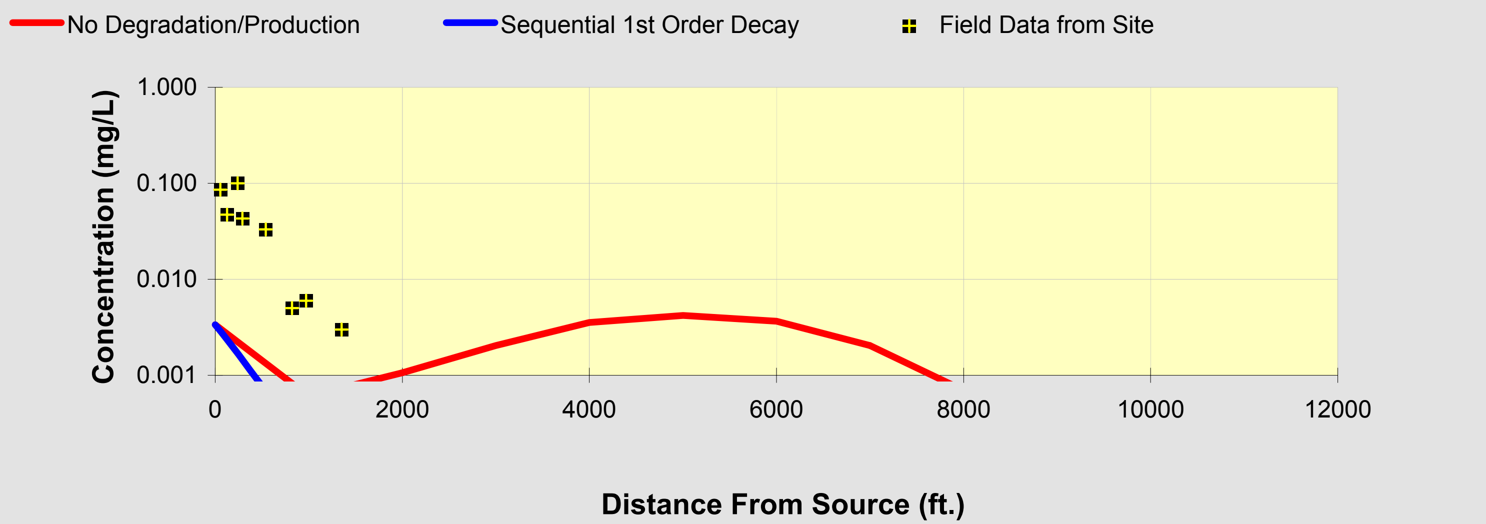
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

PCE	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
No Degradation	0.003	0.001	0.001	0.002	0.004	0.004	0.004	0.002	0.001	0.000	0.000
Biotransformation	0.0034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Monitoring Well Locations (ft)

	55	125	240	290	540	820	970	1350			
Field Data from Site	0.086	0.047	0.100	0.043	0.033	0.005	0.006	0.003			



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

250.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

APPENDIX B
REMEDIAL ACTION ALTERNATIVE COST SUMMARY SHEETS

CONTENTS

TABLES

1.0 INTRODUCTION

This appendix provides the assumptions and cost estimates for each remedial alternative. The components of each alternative and the assumptions used to derive the cost estimates are presented in the text. Following the text are the backup spreadsheets with specific assumptions used to estimate the costs associated with the four active remedial alternatives proposed for SWMUs 2, 5, 7, and 18.

2.0 PURPOSE OF ESTIMATES

Cost estimates are developed during the feasibility study (FS) primarily for the purpose of comparing remedial alternatives during the remedy selection process, not for establishing project budgets. During remedy selection, the cost estimate is typically carried over from the FS to the proposed plan for public comment. The cost estimate in the record of decision (ROD) reflects any changes to the remedial alternative that occurs during the remedy selection process as a result of new information or public comment (U.S. Environmental Protection Agency [EPA] 2000)

Cost estimates developed during the detailed analysis phase are used to compare alternatives and support remedy selection. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) includes the following language in its description of the cost criterion for the detailed analysis and remedy selection:

> “The types of costs that shall be assessed include the following: (1) Capital costs, including both direct and indirect costs; (2) Annual operations and maintenance costs; and (3) Net present value of capital and O&M costs’ (40CFR 300.430 (e)(9)(iii)(G))” (EPA 2000)

3.0 METHODOLOGY

Cost estimates for this FS report were prepared in accordance with the “Guide for Developing and Documenting Cost Estimates During the Feasibility Study” (EPA 2000). The Remedial Action Cost Engineering and Requirements (RACER™) 2004 system was the primary source of cost data (Earth Tech [Earth Tech] 2004). Costs for unique line items not included in RACER were based on vender quotes. Excel™ spreadsheets were used to tabulate costs and calculate net present values (NPV) in 2004 dollars; RACER outputs are in 2004 dollars.

3.1. DESCRIPTION OF RACER™

RACER™ is a cost modeling tool that estimates costs for all phases of remediation (Earth Tech 2004). RACER can be used to evaluate costs for interim studies and measures, remedial design and corrective measures design, remedial action and corrective action, operations and maintenance (O&M), long-term monitoring, and site close out. The system was originally developed in 1991 under U.S. Department of the Air Force funding. Numerous revisions and updates have been incorporated through several releases since RACER’s introduction.

RACER is a parametric cost modeling system that uses a patented methodology for estimating costs. The RACER cost database is a duplicate of the Environmental Cost Handling Options and Solutions (ECHOS) cost database, published by the R.S. Means Company of Kingston, MA. RACER cost estimates are based on generic engineering solutions for environmental projects, technologies, and processes. With RACER, the most technologically up-to-date engineering practices and procedures are used to accurately reflect today's remediation processes and pricing. Cost estimates in RACER are tailored specifically to each project by adding site-specific parameters to reflect project-specific conditions and requirements. The tailored design is then translated into specific quantities of work, and the quantities of work are priced using current price data.

3.2. USER-DEFINED COSTS

Because of unique characteristics for some elements of the remediation alternatives, it was not always possible to develop RACER (Earth Tech 2003) cost estimates. The costs of the enhanced bioremediation alternatives (Alternatives 3A and 3B) were estimated with a vendor quote.

4.0 COST ESTIMATE COMPONENTS

Cost estimates for the remediation alternatives include capital costs, annual O&M costs and/or periodic costs, cost of capital, net present value of O&M costs and/or periodic costs, contingency allowances, and escalation costs for dated data. Each of these is discussed in further detail in the following text.

4.1 CAPITAL COSTS

Capital costs include direct and indirect costs. Costs incurred for equipment, material, labor, construction, development and implementation of remedial technologies are included as direct costs. Indirect costs include permitting fees, health and safety items, site supervision, engineering, overhead and profit, and start up. Indirect costs are included in the estimate as either a separate line item or a percentage of the direct capital cost.

4.2 ANNUAL OPERATION AND MAINTENANCE AND/OR PERIODIC COSTS

Annual O&M costs are costs incurred after construction. These costs are necessary to assure the effectiveness of a remedial action. Annual O&M costs typically include power, operating labor, consumable materials, purchased services (for example, laboratory analyses), equipment replacement, maintenance, sampling, permit fees, and annual reports and site reviews.

Periodic costs are costs that occur once every few years or once during the entire O&M period. Examples include five-year reviews, equipment replacement, site close out, and remedy failure and replacement.

4.2.1 Discount Rate

A discount rate is similar to an interest rate and is used to account for the time value of money. A dollar is worth more today than in the future because, if invested in an alternative use today, the dollar would earn a return (that is, interest). If the capital were not employed in a specific use, it would have a productivity value in alternate uses. The choice of a discount rate is important because the selected rate directly impacts the present value of a cost estimate, which is then used in making a remedy selection decision.

EPA policy on the use of discount rates for remedial investigation (RI) and FS cost analysis is stated in the preamble to the NCP (55FR8722) and in Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-20 (EPA 1993). Discount rates used in economic analysis by the Federal government are specified in the Office of Management and Budget (OMB) Circular A-94. The discount rate on December 10, 2004 for a 4 year stream of payments is 1.9 percent, for a 5 year stream of payments is 2.1 percent, and for a 20-year stream of payments is 3.4 percent (OMB website).

4.2.2 Net Present Value

Net Present Value (NPV) analysis is a method to evaluate costs that occur over different time periods. Different remedial alternatives can be compared on the basis of a single cost for each alternative. This single number, the present value of the alternative, is the amount of money that should be set aside at the start of remediation to assure that sufficient funding will be available through the duration of the alternative.

The present value of a series of equal annual future payments such as annual O&M payments is calculated using the following equation:

$$PV = \sum_{t=1}^{n} \frac{x_t}{(1+i)^t}$$

where

PV	=	Present value
x_t	=	payment in year t (t = 0 for present or base year)
i	=	discount rate
t	=	number of years following construction that expenditure start
n	=	number of years that the stream of equal annual future payments will run

The present value of a single periodic future payment is calculated using the following equation:

$$PV = \frac{x_t}{(1+i)^t}$$

where

PV	=	Present value
x_t	=	Payment in year t (t = 0 for present or base year)
i	=	Discount rate
t	=	Number of years following construction that expenditure occur

The NPV is calculated by adding capital costs to the net present worth of O&M annual expenditure and periodic costs. NPV for this cost estimate is determined using 2004 dollars (see Section 5.4, Escalation Costs, for adjustment of capital costs)

4.3 CONTINGENCY ALLOWANCES

Contingency is factored into a cost estimate to cover unknowns, unforeseen circumstances, or unanticipated conditions that are not possible to evaluate from the data on hand at the time the estimate is prepared. The two main types of contingency are scope and bid. Scope contingency covers unknown costs resulting from scope changes that may occur during design. Bid contingency covers unknown costs associated with constructing or implementing a given project scope. Exhibit 5-6 of EPA's guide for developing cost estimates for FSs gives some expected ranges in contingency fees for certain remedial technologies (EPA 2000).

4.4 ESCALATION COSTS

No escalation factor was necessary to bring RACER output costs to 2004 dollars, as RACER 2004 output costs are presented in 2004 dollars.

5.0 COST ESTIMATE ASSUMPTIONS

This section identifies the assumptions and parameters used in developing cost estimates for cleanup at SWMUs 2, 5, 7, and 18. Table B-1 is a summary of the costs of each remedial alternative. Tables B-2 through B-5 are cost estimates for Alternatives 2, 3A, 3B and 4. No cost estimate was prepared for the no action alternative, which is not an acceptable alternative. General assumptions that were applied for all alternatives are discussed in Section 5.1. Specific assumptions for Aternatives 2, 3A, 3B and 4 are discussed in Sections 5.2 through 5.5, respectively.

5.1 GENERAL ASSUMPTIONS

The following general assumptions were used for developing costs for each of the proposed remedial alternatives: It was assumed that each technology would be implemented until the maximum contaminant level (MCL) for tetrachloroethene (5 micrograms per liter [µg/L]) is obtained. The general assumptions include:

- Although VOCs have not been detected in soil, PCE and TCE are assumed to be present in the vadose zone at concentrations requiring cleanup within the area adjacent to Building IA-12 where a waste oil tank was removed. Soil gas concentrations for PCE and TCE exceed the screening criteria for indoor vapor inhalation under the residential land use scenario. Therefore, each of the active alternatives includes a remedial technology to treat TCE and PCE contamination in the vadose zone within the area of the former waste oil tank.

- One plume of VOCs requires treatment at SWMUs 2, 5, 7, and 18. Groundwater treatment will be applied to the area of the plume containing PCE at concentrations exceeding 5 (Alternatives 2, 3B and 4) or 10 (Alternative 3A) µg/L. PCE is the VOC that is present at the highest concentrations.

- Remediation goals for groundwater are based on achieving MCLs. It was assumed that each technology would be implemented until the maximum contaminant level (MCL) for tetrachloroethene (5 micrograms per liter [µg/L]) is obtained.

- The total area of the plume in which PCE concentrations exceed 5 µg/L is approximately 208,000 square feet. The portion of the plume in which PCE concentrations exceed 10 µg/L covers approximately 31,000 square feet.

- The average depth to the water table at SWMUs 2, 5, 7, and 18 is 12 feet bgs. Groundwater within 15 feet of the water table is assumed to require treatment. Therefore, the average depth of groundwater treatment extends to a depth of 27 feet bgs.

- Project management, remedial design, construction oversight, planning documents, reporting, as-built drawings, public notice, and permitting labor are costs are based on a percentage of the total capital cost as assumed in RACER (Earth Tech 2004). Contingency factors are intended to account for changes in scope and/or bid as suggested by A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA 2000).

5.2 ALTERNATIVE 2: AIR SPARGING WITH SOIL VAPOR EXTRACTION

The following subsections provide a brief description of Alternative 2 and the assumptions used in preparation of the cost estimate, which is presented in Table B-2.

5.2.1 Alternative 2: Assumptions for Treating VOCs in the Vadose Zone

Alternative 2 includes both an air sparging system and a soil vapor extraction (SVE) system. The air sparging system injects air into the saturated zone to strip VOCs from the groundwater into the air. The SVE system recovers the air and entrained VOCs as the air moves upward into the vadose zone. Because Alternative 2 includes a component to treat the vadose zone throughout the plume, no separate treatment technology is needed to address VOCs in soil and soil gas within the area of the former waster oil tank near Building IA-12. Therefore, the assumptions for Alternative 2 are presented in Section 5.2.2, Assumptions for Treating Groundwater.

5.2.2 Alternative 2: Assumptions for Treating Groundwater

Alternative 2 consists of an air sparging system working in conjunction with a SVE system. The following assumptions were used in estimating costs for Alternative 2:

General Assumptions

- Surface area of contamination is 208,000 square feet
- Costs are based on RACER 2004 (Earth Tech 2004)
- A pilot scale test will be conducted prior to full-scale design
- Remediation timeframe is approximately 4 years, the discount rate for a 4-year project is 1.9 percent (OMB 1993)

Air Sparge

- Average sparge well depth is 29 ft, constructed of 2” Schedule 40 PVC, installed by direct push, 295 wells total, 5 cubic feet per minute in each well, 13-foot radius of influence, no equipment enclosure

Soil Vapor Extraction

- Average extraction well depth will be 25 feet, constructed of 2” Schedule 40 PVC, installed by direct push, 16-foot radius of influence, 165 wells total, 15 cubic feet per minute in each well (3750 total), no equipment enclosure

Groundwater Monitoring Well Installation

- 12 wells to be installed to 27 feet bgs, constructed of 2” Schedule 40 PVC, installed by direct push, 1 soil sample from each well will be analyzed for VOCs

Groundwater Monitoring

- Monitoring includes QA/QC samples, data management (abbreviated monitoring plan, full monitoring report, data evaluation and validation, electronic submittal)

- Average groundwater sample depth is 25 feet bgs, no samples will be collected during active air sparge, samples will be collected quarterly in years 3 and 4. Sixteen (12 from new wells, 4 from existing wells) samples will be collected per event. Samples will be analyzed for VOCs and MNA parameters, 2 QC samples and 1equipment rinsate will be included per sampling event.

Additional

- 5 KV 3 Phase Primary distribution over 600 linear feet, 250 foot pole spacing, 160 amp service, 40 foot poles

- All drill cuttings are non hazardous and will be disposed of as bulk to a permitted facility. A vendor quote was obtained for hauling and disposal. The cost will be $55 per ton for disposal to a Class II facility, $80 per ton for disposal to a Class I facility provided was is not RCRA, and $190 for disposal of RCRA waste at a Class I facility. The quote includes transportation and disposal and associated taxes. The quote was obtained on October 12, 2004, from Stuart Levang, Operations Manager at DenBeste Transportation, Inc., 820 DenBeste Court, Windsor, California 95492, (800) 838-1477.

- Close-out report will be conducted in year 4

5.3 ALTERNATIVE 3A: ENHANCED BIOREMEDIATION USING HRC OF ENTIRE PLUME

This section provides the assumptions used in preparation of the cost estimate for Alternative 3A. The detailed cost estimate for Alternative 3A is presented in Table B-3. Proposed Remedial Alternative 3A is summarized in Section 7.7.3 of the main FS text. Remedial Alternative 3A consists of enhanced bioremediation through injection of hydrogen releasing compounds (HRC) throughout the plume where PCE concentrations exceed the remedial goal of 5 µg/L.

5.3.1 Alternative 3A: Assumptions for Treating VOCs in the Vadose Zone

VOCs in the vadose zone within the area of the former waste oil tank near Building IA-12 will be treated using soil vapor extraction. The following assumptions were used in estimating costs for the SVE treatment in the vadose zone:

- One SVE well will be installed within the backfill material of the former waste oil UST. The depth of the SVE well will be 10 feet bgs with a screen interval from 5 to 10 feet bgs.

- One blower with a carbon vapor treatment unit will be used.

- The SVE system will operate for 6 months.

- One soil gas monitoring point will be installed and sampled to confirm that remediation is complete. The soil gas monitoring point will be sampled four times and the soil gas samples will be analyzed for VOCs.

5.3.2 Alternative 3A: Assumptions for Treating Groundwater

The assumptions for enhanced bioremediation of the groundwater using HRC include the following:

General Assumptions

- Surface area of contamination is 208,000 square feet
- HRC material costs are based on vendor quotes received from Regenesis, Inc. (Regenesis 2004). Drilling costs associated with in situ HRC treatment are based on vendor quotes received from ResonantSonic International (ResonantSonic 2004).
- A pilot scale test of five injection points and 3 monitoring wells will be conducted prior to full-scale design
- HRC will be injected throughout the plume where PCE concentrations currently exceed 5 µg/L.
- Remediation timeframe is approximately 5 years, the discount rate for 5-year project is 2.1 percent (OMB 1993)

Groundwater Monitoring Well Installation

- 12 wells to be installed to 27 feet bgs, constructed of 2" Schedule 40 PVC, installed by direct push, 1 soil sample from each well will be analyzed for VOCs

Injection of HRC

- Approximately 40,000 pounds of HRC will be injected between 15 and 30 feet below ground surface through 452 direct push locations for primary injection. HRC should be injected at a rate of 5.5 pounds per foot from 12 feet bgs to 27 feet below ground surface. Primary injection will take approximately 50-60 days. A follow-up secondary treatment of 50 percent of the plume area will be required to achieve remediation goals.

Groundwater Monitoring

- Monitoring includes QA/QC samples, data management (abbreviated monitoring plan, full monitoring report, data evaluation and validation, electronic submittal)
- Average groundwater sample depth is 25 feet bgs, samples will be collected quarterly in years 1 and 2 and semi-annually in years 3 through 5. Sixteen (12 from new wells, 4 from existing wells) samples will be collected per event. Samples will be analyzed for VOCs and MNA parameters, 2 QC samples and 1equipment rinsate will be included per sampling event.

Additional

- Close-out report will be conducted in year 5

5.4 ALTERNATIVE 3B: ENHANCED BIOREMEDIATION USING HRC OF MAIN PORTION OF PLUME

This section provides the assumptions used in preparation of the cost estimate for Alternative 3B. The detailed cost estimate for Alternative 3B is presented in Table B-4. Proposed Remedial Alternative 3B is summarized in Section 7.7.4 of the main FS text. Remedial Alternative 3B consists of enhanced bioremediation through injection of hydrogen releasing compounds (HRC) within the main portion of the plume where PCE concentrations exceed 10 µg/L. Monitored natural attenuation would be used to restore water quality to remedial goals in the remainder of the plume.

5.4.1 Alternative 3B: Assumptions for Treating VOCs in the Vadose Zone

Soil vapor extraction will be used to treat VOCs in the vadose zone within the area of the former waste oil tank near Building IA-12. Therefore, the assumptions for treating VOCs in the vadose zone for Alternative 3B are the same as the assumptions for Alternative 3A. Please see Section 5.3.1.

5.4.2 Alternative 3B: Assumptions for Treating Groundwater

The assumptions for enhanced bioremediation of the groundwater using HRC in the main portion of the plume and MNA in the remainder of the plume include the following:

General Assumptions

- Surface area of treatment is 31,000 square feet
- HRC material costs are primarily based on vendor quotes received from Regenesis, Inc. (Regenesis 2004). Drilling costs associated with in situ HRC treatment are primarily based on vendor quotes received from ResonantSonic International (ResonantSonic 2004).
- A pilot scale test of five injection points and 3 monitoring wells will be conducted prior to full-scale design
- HRC will be injected throughout the plume where PCE concentrations currently exceed 10 µg/L.
- Remediation timeframe is approximately 20 years, the discount rate for a 20-year project is 3.2 percent (OMB 1993)

Groundwater Monitoring Well Installation

- 12 wells to be installed to 27 feet bgs, constructed of 2” Schedule 40 PVC, installed by direct push, 1 soil sample from each well will be analyzed for VOCs

Injection of HRC

- Approximately 6,600 pounds of HRC will be injected between 15 and 30 feet below ground surface through 80 direct push locations for primary injection. HRC should be injected at a rate of 5.5 pounds per foot. Primary inject will take approximately 9-10 days. A follow-up secondary treatment of 50 percent of the plume area will be required to achieve remediation goals.

Groundwater Monitoring

- Monitoring includes QA/QC samples, data management (abbreviated monitoring plan, full monitoring report, data evaluation and validation, electronic submittal)
- Average groundwater sample depth is 25 feet bgs, samples will be collected quarterly in years 1 and 2, semi-annually in years 3 through 5, and annually in years 6 through 20. Sixteen (12 from new wells, 4 from existing wells) samples will be collected per event. Samples will be analyzed for VOCs and MNA parameters, 2 QC samples and 1equipment rinsate will be included per sampling event.

Additional

- Five-year reviews will be conducted in years 5, 10 and 15
- Close-out report will be conducted in year 20
- For purposes of this estimate, no changes in land use were assumed.

5.5 ALTERNATIVE 4: PUMP AND TREAT WITH AIR STRIPPING

This section provides the assumptions used in preparation of the cost estimate for Alternative 4. The detailed cost estimate for Alternative 4 is presented in Table B-5. Proposed Remedial Alternative 3B is summarized in Section 7.7.5 of the main FS text. Remedial Alternative 4 consists of pump and treat with air stripping. Monitored natural attenuation would be used to restore water quality to remedial goals in the remainder of the plume.

5.5.1 Alternative 4: Assumptions for Treating VOCs in the Vadose Zone

Soil vapor extraction will be used to treat VOCs in the vadose zone within the area of the former waste oil tank near Building IA-12. Therefore, the assumptions for treating VOCs in the vadose zone for Alternative 4 are the same as the assumptions for Alternative 3A. Please see Section 5.3.1 for a description of the assumptions.

5.5.2 Alternative 4: Assumptions for Pump and Treat

General Assumptions

- Surface area of contamination is 208,000 square feet
- Depth to groundwater is 12 feet bgs

- Depth to base of contamination is 27 ft bgs (15 foot contaminated interval)
- Costs are based on RACER 2004 (Earth Tech 2004)
- Remediation timeframe is approximately 20 years, the discount rate for a 20-year project is 3.2 percent (OMB website)

Groundwater Monitoring Well Installation

- 12 wells to be installed to 27 feet bgs, constructed of 2” Schedule 40 PVC, installed by direct push, 1 soil sample from each well will be analyzed for VOCs

Groundwater Extraction Wells

- A total of 16 groundwater extraction wells will be installed with 3 gpm flow rate per well. Each well will have a 4” submersible pump, capable of pumping 0.3 to 7 gallons per minutes
- Wells will be constructed of 6” Schedule 40 PVC by direct push, will have a 6” casing above ground, and a 9’ screen. Extracted groundwater will be conveyed to the air stripping unit by 2000 linear feet of 1” Schedule 80 PVC connection piping
- One 5,000 gallon single wall steel tank will be used for effluent collection

Air Stripping

- Influent into the tower will be 48 gallons per minute, contaminant (PCE) is expected to be of very high volatility with 95 percent removal of contaminants expected
- Air stripper will consist of one packed tower, 2 feet in diameter, and 10 feet tall. Two permanent modular carbon adsorbers in series with a blower system will be included to help achieve discharge requirements
- Effluent water will discharge at a rate of 48 gallons per minute

Discharge to Publicly Owned Treatment Works (POTW)

- POTW is off-site, water will be delivered by the sewer at a rate of approximately 48 gallons per minute. The Class II Industrial Use Permit connection fee to the Contra Costa County Sanitary Sewer is $4300, with $2.60 additional per hundred cubic feet (750 gallons).
- 200 linear feet of connection, 6” PVC sanitary piping, gravity flow, in trench 1.5’ wide by 5’ deep, will be used to transport the water to the sewer.
- Discharge water will be sampled four times in the first year and analyzed for pH, cyanide, oil and grease, phenols, VOCs, total metals, and mercury based on groundwater discharge permit requirements. Discharge water will be sampled one time during each subsequent year for 19 years analyzed for pH, cyanide, oil and grease, phenols, VOCs, total metals, and mercury.

Groundwater Monitoring

- Monitoring includes QA/QC samples, data management (abbreviated monitoring plan, full monitoring report, data evaluation and validation, electronic submittal)
- Average groundwater sample depth is 25 feet bgs, samples will be collected quarterly in years 1 and 2, semi-annually in years 3 through 5, and annually in years 6 through 20. Sixteen (12 from new wells, 4 from existing wells) samples will be collected per event. Samples will be analyzed for VOCs and MNA parameters, 2 QC samples and 1 equipment rinsate will be included per sampling event.

Additional

- Five-year reviews will be conducted in years 5, 10 and 15
- Close-out report will be conducted in year 20
- For purposes of this estimate, no changes in land use were assumed.

REFERENCES

Earth Tech. 2004. "Remedial Action Cost Engineering and Requirements System Parametric Cost-Estimating Software for Remediation and Restoration Projects." RACER™. Version 6.0.0.

Office of Management and Budget (OMB website). "OMB Circular No. A-94, Appendix C, Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses." January. On-Line address: http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html. Accessed on December 10, 2004.

Regenesis, Inc. (Regenesis). 2004. Personnel communication between John Bosche of Tetra Tech and David Reilly, Regenesis, Inc. to obtain vendor quote. December 13, 2004.

ResonantSonic International. (Resonant Sonic). 2204. Personnel communication between Tara Sweet of Tetra Tech and Tuan Nguyen of Resonant Sonic, Inc. to obtain vendor quote. December 13, 2004.

U.S. Environmental Protection Agency (EPA). 2000. "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study." EPA/540/R-00/002. Washington, D.C. July.

TABLES

TABLE B-1: COST SUMMARY FOR REMEDIAL ALTERNATIVES
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COMPARISON OF TOTAL COST OF REMEDIAL ALTERNATIVES

Site:	SWMUs 2, 5, 7, and 18	**Base Year:**	2004
Location:	Naval Weapons Station Seal Beach, Detachment Concord	**Date:**	December 10, 2004
Phase:	Feasibility Study		

	Alternative 2	Alternative 3A	Alternative 3B	Alternative 4
Description	**Air Sparge, SVE, Monitoring**	**SVE Treatment of Vadose Zone, HRC Treatment of Entire Plume, Monitoring**	**SVE Treatment of Vadose Zone, HRC Treatment of Main Portion of Plume, Monitoring**	**SVE Treatment of Vadose Zone, Pump and Treat with Air Stripping fo Entire Plume, Monitoring**
Total Project Duration (Years)	4	5	20	20
Capital Cost	$2,825,933	$1,069,683	$694,998	$1,046,460
Annual O & M Cost	$1,516,372	$749,202	$1,423,649	$10,540,822
Total Periodic Cost	$24,988	$69,086	$101,749	$84,189
Total Present Value of Alternative	**$4,367,292**	**$1,887,971**	**$2,220,395**	**$11,671,471**

TABLE B-2 ALTERNATIVE 2 AIR SPARGING WITH SOIL VAPOR EXTRACTION TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. In situ treatment of contaminated groundwater by air sparging and soil vapor extraction processes. Quarterly groundwater monitoring for 2 years following active treatment. Total remedial timeframe is 4 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
CAPITAL COSTS[a]:							
Start-up Costs							
Other Direct Costs	1.00	LS	25449.05	31079.37	12837.13	$69,366	
Air Sparging (295 wells installed to 29 ft bgs)							
Organic Vapor Analyzer Rental, per Day	111.00	DAY	165.99	0.00	0.00	$18,425	
Direct Push Rig, Truck Mounted, Non Hydraulic, Includes Labor, Sampling, Decontamination	141.00	DAY	248.99	0.00	0.00	$35,108	
Mobilize Direct Push Rig and Crew	141.00	DAY	829.96	0.00	0.00	$117,024	
Demobilize Direct Push Rig and Crew	141.00	DAY	829.96	0.00	0.00	$117,024	
Air Sparge System, Blower 163 SCFM, 15 HP, 15 PSI, base, intake filter, silencer, pulleys, belt, belt guard.	10.00	EA	17296.18	0.00	0.00	$172,962	
Field Technician	1,776.00	HR	0.00	123.28	0.00	$218,945	
2" PVC, Schedule 40, Well Casing	7,965.00	LF	1.63	7.80	9.52	$150,937	
2" PVC, Schedule 40, Well Screen	590.00	LF	3.77	10.06	12.29	$15,411	
2" PVC, Well Plug	295.00	EA	7.94	11.70	14.29	$10,009	
Furnish 55 Gallon Drum for Drill Cuttings & Development Water	452.00	EA	114.10	0.00	0.00	$51,573	
2" Screen, Filter Pack	1,180.00	LF	4.23	6.63	8.10	$22,373	
2" Well, Portland Cement Grout	7,080.00	LF	1.58	0.00	0.00	$11,186	
2" Well, Bentonite Seal	295.00	EA	12.59	26.33	32.14	$20,963	
2" PVC, Schedule 80, Connection Piping	4,425.00	LF	1.21	8.48	0.00	$42,878	
4" PVC, Schedule 80, Manifold Piping	2,950.00	LF	3.61	18.26	0.00	$64,517	
2" PVC, Schedule 80, Tee	295.00	EA	17.34	0.00	0.00	$5,115	
2" PVC, Schedule 80, 90 Degree, Elbow	295.00	EA	4.71	0.00	0.00	$1,389	
4" x 2" Reducer, PVC Schedule 80	295.00	EA	50.79	0.00	0.00	$14,983	
2" PVC, Sch 80, Ball Valve	295.00	EA	121.19	0.00	0.00	$35,751	
Pressure Gauge	295.00	EA	95.66	123.86	0.00	$64,758	
SUBTOTAL						**$1,191,332**	
Soil Vapor Extraction (165 wells installed to 25 ft bgs)							
Organic Vapor Analyzer Rental, per Day	54.00	DAY	165.99	0.00	0.00	$8,963	
Direct Push Rig, Truck Mounted, Non Hydraulic, Includes Labor, Sampling, Decontamination	82.00	DAY	248.99	0.00	0.00	$20,417	
Mobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Demobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
1000 SCFM, Vapor Recovery System	3.00	EA	36,356.24	0.00	0.00	$109,069	
Field Technician	864.00	HR	0.00	123.28	0.00	$106,514	
2" PVC, Schedule 40, Well Casing	2,475.00	LF	1.63	7.80	9.52	$46,901	
2" PVC, Schedule 40, Well Screen	1,650.00	LF	3.77	10.06	12.29	$43,098	
2" PVC, Well Plug	165.00	EA	7.94	11.70	14.29	$5,598	
Furnish 55 Gallon Drum for Drill Cuttings & Development Water	218.00	EA	114.10	0.00	0.00	$24,874	
2" Screen, Filter Pack	1,980.00	LF	4.23	6.63	8.10	$37,541	
2" Well, Portland Cement Grout	1,980.00	LF	1.58	0.00	0.00	$3,128	
2" Well, Bentonite Seal	165.00	EA	12.59	26.33	32.14	$11,725	
2" PVC, Schedule 80, Connection Piping	4,331.25	LF	1.21	8.48	0.00	$41,970	
4" PVC, Schedule 80, Manifold Piping	2,887.50	LF	3.61	18.26	0.00	$63,150	
2" PVC, Schedule 80, Tee	165.00	EA	17.34	0.00	0.00	$2,861	
2" PVC, Schedule 80, 90 Degree, Elbow	165.00	EA	4.71	0.00	0.00	$777	
4" PVC, Schedule 80, 90 Degree, Elbow	165.00	EA	19.49	0.00	0.00	$3,216	
4" x 2" Reducer, PVC Schedule 80	165.00	EA	50.79	0.00	0.00	$8,380	
2" PVC, Sch 80, Ball Valve	165.00	EA	121.19	0.00	0.00	$19,996	
Pressure Gauge	165.00	EA	95.66	123.86	0.00	$36,221	
SUBTOTAL						**$596,060**	
Overhead Electrical Distribution							
1/0 ACSR Conductor	1908.00	LF	0.31	1.61	0.07	$3,797	
1/C #2 Aluminum, Bare, Wire	796.00	LF	0.23	1.55	0.07	$1,473	
40' Class 3 Treated Power Pole	4.00	EA	458.57	907.33	61.07	$5,708	
Straight-line Structure, 5 KV Pole Top	2.00	EA	156.66	817.63	55.03	$2,059	
Terminal Structure, 5 KV Pole Top	2.00	EA	1770.67	3102.52	208.81	$10,164	
5 KV, 3/0, Shielded Cable, Copper	120.00	LF	3.85	3.99	0.27	$973	
5 KV, 1/0 to 4/0 Conductor, Terminations & Splicing	6.00	EA	683.44	619.29	0.00	$7,816	
4" Rigid Steel Conduit	40.00	LF	13.54	24.95	0.00	$1,540	
SUBTOTAL						**$33,529**	

TABLE B-2 ALTERNATIVE 2 AIR SPARGING WITH SOIL VAPOR EXTRACTION TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. In situ treatment of contaminated groundwater by air sparging and soil vapor extraction processes. Quarterly groundwater monitoring for 2 years following active treatment. Total remedial timeframe is 4 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
Residual Waste Management (Soil)							
T & D of Debris to a Class I Facility, Assuming RCRA Stabilization for Lead	0.00	TON	0.00	192.91	0.00	$0	
T & D of Debris to a Class I Facility, Assuming Cal-Haz Material	0.00	TON	0.00	80.21	0.00	$0	
T & D of Debris to a Class II Facility	376.00	TON	0.00	55.20	0.00	$20,755	
TCLP (RCRA) (EPA 1311), Soil Analysis	2.00	EA	821.93	0.00	0.00	$1,644	
SUBTOTAL						**$22,399**	
Installation of Groundwater Monitoring Wells (12 wells to 27 ft bgs)							
Organic Vapor Analyzer Rental, per Day	5.00	DAY	165.99	0.00	0.00	$830	
Direct Push Rig, Truck Mounted, Non Hydraulic, Includes Labor, Sampling, Decontamination	5.00	DAY	248.99	0.00	0.00	$1,245	
Mobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Demobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Volatile Organic Analysis (SW 5035/SW 8260B), Soil Analysis	24.00	EA	296.90	0.00	0.00	$7,126	
Field Technician	120.00	HR	0.00	123.28	0.00	$14,794	
2" PVC, Schedule 40, Well Casing	204.00	LF	1.63	7.80	9.52	$3,866	
2" PVC, Schedule 40, Well Screen	120.00	LF	3.77	10.06	12.29	$3,134	
2" PVC, Well Plug	12.00	EA	7.94	11.70	14.29	$407	
Split Spoon Sampling	72.00	LF	0.00	33.43	40.82	$5,346	
Furnish 55 Gallon Drum for Drill Cuttings & Development Water	18.00	EA	114.10	0.00	0.00	$2,054	
2" Screen, Filter Pack	144.00	LF	4.23	6.63	8.10	$2,730	
2" Well, Portland Cement Grout	168.00	LF	1.58	0.00	0.00	$265	
2" Well, Bentonite Seal	12.00	EA	12.59	26.33	32.14	$853	
SUBTOTAL						**$44,310**	
SUBTOTAL						$1,923,384	
Contingency		25%				$480,846	10% scope + 15% bid
SUBTOTAL						**$2,404,231**	
Professional Labor Management[a]							
Design and Work Plan		8.00%				$192,338	
Project Management Labor Cost		2.00%				$48,085	
Planning Documents Labor Cost		2.00%				$48,085	
Construction Oversight Labor Cost		2.50%				$60,106	
Reporting Labor Cost		0.25%				$6,011	
As-Built Drawings Labor Cost		0.25%				$6,011	
Public Notice Labor Cost		0.04%				$962	
Site Closure Activities Labor Cost		0.00%				$0	
Permitting Labor Cost		2.50%				$60,106	
SUBTOTAL						421702.0445	
TOTAL CAPITAL COST IN 2004 DOLLARS						**$2,825,933**	
OPERATIONS AND MAINTENANCE COSTS[a]:							
Treatment Train Miscellaneous							active treatment
Disposable Gloves (Latex)	273.00	PAIR	0.33	0.00	0.00	$23,040	
Disposable Coveralls (Tyvek)	273.00	EA	6.66	0.00	0.00	$6,826	
Non Haz Drummed Site Waste - Load,	7.00	EA	306.24	0.00	0.00	$72	
Transp, & Landfill Disp (55-Gal Drums)						$1,528	
DOT Steel Drum, 55 Gallon	7.00	EA	115.61	0.00	0.00	$1,943	
Annual Maintenance Materials and Labor	1.00	LS	15821.94	19621.97	8152.79		
SUBTOTAL						**$194,769**	
Air Sparging							active treatment
Staff Engineer	70.00	HR	0.00	183.69	0.00	$10,216	
Field Technician	347.00	HR	0.00	123.28	0.00	$34,784	
Electrical Charge	821250.00	KWH	0.10	0.00	0.00	$81,622	
SUBTOTAL						**$126,622**	
Soil Vapor Extraction							active treatment
Staff Engineer	113.00	HR	0.00	183.69	0.00	$14,101	
Field Technician	562.00	HR	0.00	123.28	0.00	$47,717	
Electrical Charge	164250.00	KWH	0.10	0.00	0.00	$80,041	
SUBTOTAL						**141859.61**	
Runtime Percent Cost Adjustment	97%					449353.4506	
Contingency	25%					112338.3627	10% scope + 15% bid
SUBTOTAL						**$561,692**	

TABLE B-2 ALTERNATIVE 2 AIR SPARGING WITH SOIL VAPOR EXTRACTION TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. In situ treatment of contaminated groundwater by air sparging and soil vapor extraction processes. Quarterly groundwater monitoring for 2 years following active treatment. Total remedial timeframe is 4 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
Groundwater Monitoring (Years 3 and 4)							16 wells sampled quarterly
Disposable Materials per Sample	76.00	EA	12.14	0.00	0.00	$923	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	76.00	EA	10.84	0.00	0.00	$824	per sampling event
Nylon Tubing, 1/4" Outside Diameter	1625.00	LF	0.63	0.00	0.00	$1,024	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	4.00	WK	95.45	0.00	0.00	$382	
Flow Through Monitor, Weekly Rental	4.00	WK	323.68	0.00	0.00	$1,295	
Water Quality Parameter Testing Device	4.00	WK	344.33	0.00	0.00	$1,377	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	71.00	EA	47.87	0.00	0.00	$3,399	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	76.00	EA	37.11	0.00	0.00	$2,820	
Volatile Organic Analysis (EPA 624), Water Analysis	76.00	EA	296.90	0.00	0.00	$22,564	
Sulfate (EPA 300.0), Water Analysis	76.00	EA	27.94	0.00	0.00	$2,123	
Sulfide (EPA 376.1), Water Analysis	76.00	EA	40.89	0.00	0.00	$3,108	
Ferrous Iron (S.M. 3500 Fe - D)	76.00	EA	129.55	0.00	0.00	$9,846	
4" Submersible Pump Rental, Week	4.00	WK	329.12	0.00	0.00	$1,316	
Car or Van Mileage Charge	900.00	MI	0.52	0.00	0.00	$468	
Project Manager	6.00	HR	0.00	307.79	0.00	$1,847	
Project Engineer	30.00	HR	0.00	196.52	0.00	$5,896	
Project Scientist	382.00	HR	0.00	186.88	0.00	$71,388	
Staff Scientist	80.00	HR	0.00	153.23	0.00	$12,258	
Field Technician	170.00	HR	0.00	123.28	0.00	$20,958	
Word Processing/Clerical	50.00	HR	0.00	97.18	0.00	$4,859	
Draftsman/CADD	46.00	HR	0.00	127.43	0.00	$5,862	
SUBTOTAL						**$174,536**	
Contingency	25%					$43,634	10% scope + 15% bid
SUBTOTAL						**$218,170**	
SUBTOTAL (Years 1 and 2) including 25% contingency						**$561,692**	
SUBTOTAL (Years 3 and 4) including 25% contingency						**$218,170**	

PERIODIC COSTS[a]:	**Year**	Quantity	Unit	Labor Unit Cost	Extended Cost	Notes
Well Abandonment	4	16.00	EA	837.00	$13,392	
Remedial Action Report	4	1.00	EA	21553.13	$21,553	Close out report
Contingency		25%			$5,388	10% scope + 15% bid
SUBTOTAL					**$26,941**	

PRESENT VALUE ANALYSES:

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factorb	Present Value	Notes
Capital Cost	0	$2,825,933	$2,825,933	1.0000	$2,825,933	
Annual O&M	1-2	$1,123,384	$561,692	1.9444	$1,092,159	Active treatment
Annual O&M	3-4	$436,341	$218,170	1.9444	$424,213	Groundwater monitoring
Periodic Cost	4	$26,941	$26,941	0.9275	$24,988	Well abandonment, Close-out Report
		$4,412,598			**$4,367,292**	

TOTAL PRESENT VALUE OF ALTERNATIVE 2 $\boxed{\$4,367,292}$

Notes:
a Costs provided by RACER 2004
b Discount factor = $\frac{1}{(1+i)^t}$ where i = 0.019 and t = year (i.e., the present value of the dollar paid in year t at 1.9%)
c Multi-year discount factor = $\frac{(1+i)^n - 1}{i(1+i)^n}$ where i = 0.019 for a 4 year technology, t = year, and n = total number of years (i.e., the present value of the dollar paid per year from year 1 to year n at 1.9%)

TABLE B-3 ALTERNATIVE 3A ENHANCED BIOREMEDAITION USING HRC OF ENTIRE PLUME TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Addition of hydrogen release compounds to contaminated groundwater(entire plume) in two injections over three years. Quarterly groundwater monitoring during first two years of active treatment, annual monitoring for three years thereafter. Total remedial timeframe is 5 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
CAPITAL COSTS[a]:							
Vadose Zone							
Soil Vapor Extraction							
Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	2,543.68	3,458.87	$6,003	
Organic Vapor Analyzer Rental, per Day	1.00	DAY	176.27	0.00	0.00	$176	
1 HP, 230V, 98 SCFM, Vapor Recovery System	1.00	EA	5,686.86	1,302.80	0.00	$6,990	
Decontaminate Rig, Augers, Screen (Rental Equipment)	1.00	DAY	173.49	0.00	0.00	$173	
Field Technician	16.00	HR	0.00	127.93	0.00	$2,047	
2" PVC, Schedule 40, Well Casing	5.00	LF	1.73	8.48	11.53	$109	
2" PVC, Schedule 40, Well Screen	5.00	LF	4.00	10.94	14.87	$149	
2" PVC, Well Plug	1.00	EA	8.43	12.72	17.29	$38	
Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	11.00	LF	0.00	23.25	31.62	$604	
2" Screen, Filter Pack	7.00	LF	4.50	7.21	9.80	$151	
2" Well, Portland Cement Grout	2.00	LF	1.67	0.00	0.00	$3	
2" Well, Bentonite Seal	1.00	EA	13.37	28.62	38.91	$81	
2" PVC, Schedule 80, Connection Piping	16.50	LF	1.28	9.22	0.00	$173	
2" PVC, Schedule 80, Tee	1.00	EA	18.41	0.00	0.00	$18	
2" PVC, Schedule 80, 90 Degree, Elbow	1.00	EA	5.01	0.00	0.00	$5	
2" PVC, Sch 80, Ball Valve	1.00	EA	128.70	0.00	0.00	$129	
Pressure Gauge	1.00	EA	101.59	134.63	0.00	$236	
Carbon Adsorption GGas)							
8" Structural Slab on Grade	15.00	SF	5.92	8.92	0.60	$232	
Saturation Indicator	1.00	EA	75.13	0.00	0.00	$75	
Monitoring Port with Gas Monitor	2.00	EA	1.63	46.32	0.00	$96	
50 CFM, 110 Lb Fill, Closed Upflow, 7.0" Pressure Drop	1.00	EA	726.30	249.38	0.00	$976	
50 CFM, 7" Pressure, 3/4 HP, Blower System	1.00	EA	1,302.34	433.24	0.00	$1,736 $0	
Pressure Gauge	2.00	EA	101.59	134.63	0.00	$472	
Soil Vapor Sampling							
Monitoring Gas Vents	4.00	EA	0.00	34.38	0.00	$138	
Tentative ID Compunds, GC/MS, Air (30/5041/8260B - TO-14), Air Analysis	5.00	EA	236.47	0.00	0.00	$1,182	
SUBTOTAL						**$21,991**	
Installation of Groundwater Monitoring Wells (12 wells to 27 ft bgs)							12 new wells
Organic Vapor Analyzer Rental, per Day	5.00	DAY	165.99	0.00	0.00	$830	
Direct Push Rig, Truck Mounted, Non Hydraulic, Includes Labor, Sampling, Decontamination	5.00	DAY	248.99	0.00	0.00	$1,245	
Mobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Demobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Volatile Organic Analysis (SW 5035/SW 8260B), Soil Analysis	24.00	EA	296.90	0.00	0.00	$7,126	
Field Technician	120.00	HR	0.00	123.28	0.00	$14,794	
2" PVC, Schedule 40, Well Casing	204.00	LF	1.63	7.80	9.52	$3,866	
2" PVC, Schedule 40, Well Screen	120.00	LF	3.77	10.06	12.29	$3,134	
2" PVC, Well Plug	12.00	EA	7.94	11.70	14.29	$407	
Split Spoon Sampling	72.00	LF	0.00	33.43	40.82	$5,346	
Furnish 55 Gallon Drum for Drill Cuttings & Development Water	18.00	EA	114.10	0.00	0.00	$2,054	
2" Screen, Filter Pack	144.00	LF	4.23	6.63	8.10	$2,730	
2" Well, Portland Cement Grout	168.00	LF	1.58	0.00	0.00	$265	
2" Well, Bentonite Seal	12.00	EA	12.59	26.33	32.14	$853	
SUBTOTAL						**$44,310**	
HRC Injection and Materials[b]							
Pilot Test							
Work Plan						$10,000	
HRC material	420.00	LB	5.75	0.00	0.00	$2,415	
Shipping and Sales Tax	420.00	LB	0.64	0.00	0.00	$268	
Mobilization[c]	1.00	LS	0.00	0.00	0.00	$600	
Drill Rig[c]	1.00	DAY	0.00	0.00	1750.00	$1,750	
Injection Pump[c]	1.00	DAY	0.00	0.00	325.00	$325	
Borehole Abandonment[c]	75.00	LF	0.00	0.00	1.00	$75	Upper 15 feet will be abandoned
Steam Cleaner[c]	1.00	DAY	0.00	0.00	95.00	$95	
Staff Scientist[a]	78.00	HR	0.00	140.14	0.00	$10,931	

TABLE B-3 ALTERNATIVE 3A ENHANCED BIOREMEDAITION USING HRC OF ENTIRE PLUME TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Addition of hydrogen release compounds to contaminated groundwater(entire plume) in two injections over three years. Quarterly groundwater monitoring during first two years of active treatment, annual monitoring for three years thereafter. Total remedial timeframe is 5 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
Pilot Test Groundwater Monitoring[a]							3 wells sampled quarterly
RSK175 analysis for dissolved gases	14.00	EA	97.83	0.00	0.00	$1,370	
Disposable Materials per Sample	14.00	EA	10.76	0.00	0.00	$151	
Decontamination Materials per Sample	14.00	EA	9.68	0.00	0.00	$136	
Nylon Tubing, 1/4" Outside Diameter	325.00	LF	0.56	0.00	0.00	$182	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	14.00	WK	88.82	0.00	0.00	$1,243	
Flow Through Monitor, Weekly Rental	4.00	WK	301.20	0.00	0.00	$1,205	
Water Quality Parameter Testing Device	4.00	WK	307.24	0.00	0.00	$1,229	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	14.00	EA	55.69	0.00	0.00	$780	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	14.00	EA	38.58	0.00	0.00	$540	
Volatile Organic Analysis (EPA 624), Water Analysis	14.00	EA	276.27	0.00	0.00	$3,868	
Chloride (EPA 300), Water Analysis	14.00	EA	28.41	0.00	0.00	$398	
Sulfate (EPA 300.0), Water Analysis	14.00	EA	28.94	0.00	0.00	$405	
Sulfide (EPA 376.1), Water Analysis	14.00	EA	49.10	0.00	0.00	$687	
Ferrous Iron (S.M. 3500 Fe - D)	14.00	EA	146.31	0.00	0.00	$2,048	
55 Gallon 17C Closed Head Steel Drum	4.00	EA	91.19	0.00	0.00	$365	
4" Submersible Pump Rental, Day	4.00	DAY	103.31	0.00	0.00	$413	
Car or Van Mileage Charge	400.00	MI	0.48	0.00	0.00	$192	
Project Scientist	63.00	HR	0.00	146.81	0.00	$9,249	
Field Technician	71.00	HR	0.00	97.98	0.00	$6,957	
Word Processing/Clerical	7.00	HR	0.00	81.20	0.00	$568	
Draftsman/CADD	7.00	HR	0.00	125.83	0.00	$881	
Primary Treatment							
HRC material	40020.00	LB	5.75	0.00	0.00	$230,115	
Shipping and Sales Tax	40020.00	LB	0.64	0.00	0.00	$25,564	
Mobilization[c]	1.00	LS	0.00	0.00	0.00	$600	
Drill Rig[c]	55.00	DAY	0.00	0.00	1750.00	$96,250	Drilling 240 feet per day
Injection Pump[c]	55.00	DAY	0.00	0.00	325.00	$17,875	
Borehole Abandonment[c]	6780.00	LF	0.00	0.00	1.00	$6,780	Only upper 15 feet will be abandoned
Steam Cleaner[c]	55.00	DAY	0.00	0.00	95.00	$5,225	
Hand Auger[c]	2.00	DAY	0.00	0.00	750.00	$1,500	Assumes 8 cores per day
Local Travel for Hand Auger Crew[c]	2.00	DAY	0.00	150.00	0.00	$300	
Concrete Coring[c]	2.00	DAY	0.00	0.00	1100.00	$2,200	Assumes 8 cores per day
Local Travel for Concrete Coring Crew[c]	2.00	DAY	0.00	150.00	0.00	$300	
Car or Van Mileage Charge[a]	11000.00	MI	0.48	0.00	0.00	$5,280	
Follow up Treatment (50% Retreat, If Necessary)							
HRC material	20010.00	LB	5.75	0.00	0.00	$115,058	
Shipping and Sales Tax	20010.00	LB	0.64	0.00	0.00	$12,782	
Mobilization[c]	1.00	LS	0.00	0.00	0.00	$600	
Drill Rig[c]	23.00	DAY	0.00	0.00	1750.00	$40,250	Drilling 240 feet per day
Injection Pump[c]	23.00	DAY	0.00	0.00	325.00	$7,475	
Borehole Abandonment[c]	3390.00	LF	0.00	0.00	1.00	$3,390	Only upper 15 feet will be abandoned
Steam Cleaner[c]	23.00	DAY	0.00	0.00	95.00	$2,185	
Hand Auger[c]	1.00	DAY	0.00	0.00	750.00	$750	Assumes 8 cores per day
Local Travel for Hand Auger Crew[c]	1.00	DAY	0.00	150.00	0.00	$150	
Concrete Coring[c]	1.00	DAY	0.00	0.00	1100.00	$1,100	Assumes 8 cores per day
Local Travel for Concrete Coring Crew[c]	1.00	DAY	0.00	150.00	0.00	$150	
Car or Van Mileage Charge[a]	5500.00	MI	0.48	0.00	0.00	$2,640	
SUBTOTAL all HRC Material and Injections						**$637,843**	
SUBTOTAL						$704,144	
Contingency		25%				$176,036	10% scope + 15% bid
SUBTOTAL						**$880,180**	
Professional Labor Management[a]							
Design and Work Plan		8.00%				$70,414	
Project Management Labor Cost		2.50%				$22,004	
Planning Documents Labor Cost		2.50%				$22,004	
Construction Oversight Labor Cost		2.75%				$24,205	
Reporting Labor Cost		0.35%				$3,081	
As-Built Drawings Labor Cost		0.35%				$3,081	
Public Notice Labor Cost		0.08%				$704	
Site Closure Activities Labor Cost		0.00%				$0	
Permitting Labor Cost		5.00%				$44,009	
SUBTOTAL						**$189,503**	
TOTAL CAPITAL COST IN 2004 DOLLARS						**$1,069,683**	

TABLE B-3 ALTERNATIVE 3A ENHANCED BIOREMEDAITION USING HRC OF ENTIRE PLUME TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Addition of hydrogen release compounds to contaminated groundwater(entire plume) in two injections over three years. Quarterly groundwater monitoring during first two years of active treatment, annual monitoring for three years thereafter. Total remedial timeframe is 5 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
OPERATIONS AND MAINTENANCE COSTS[a]:							
Groundwater Monitoring (Years 1 and 2)							16 wells samples quarterly
Disposable Materials per Sample	76.00	EA	12.14	0.00	0.00	$923	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	76.00	EA	10.84	0.00	0.00	$824	per sampling event
Nylon Tubing, 1/4" Outside Diameter	1625.00	LF	0.63	0.00	0.00	$1,024	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	4.00	WK	95.45	0.00	0.00	$382	
Flow Through Monitor, Weekly Rental	4.00	WK	323.68	0.00	0.00	$1,295	
Water Quality Parameter Testing Device	4.00	WK	344.33	0.00	0.00	$1,377	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	76.00	EA	47.87	0.00	0.00	$3,638	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	76.00	EA	37.11	0.00	0.00	$2,820	
Volatile Organic Analysis (EPA 624), Water Analysis	76.00	EA	296.90	0.00	0.00	$22,564	
Sulfate (EPA 300.0), Water Analysis	76.00	EA	27.94	0.00	0.00	$2,123	
Sulfide (EPA 376.1), Water Analysis	76.00	EA	40.89	0.00	0.00	$3,108	
Ferrous Iron (S.M. 3500 Fe - D)	76.00	EA	129.55	0.00	0.00	$9,846	
4" Submersible Pump Rental, Week	4.00	WK	329.12	0.00	0.00	$1,316	
Car or Van Mileage Charge	900.00	MI	0.52	0.00	0.00	$468	
Project Manager	4.00	HR	0.00	307.79	0.00	$1,231	
Project Engineer	30.00	HR	0.00	196.52	0.00	$5,896	
Project Scientist	382.00	HR	0.00	186.88	0.00	$71,388	
Staff Scientist	80.00	HR	0.00	153.23	0.00	$12,258	
Field Technician	170.00	HR	0.00	123.28	0.00	$20,958	
Word Processing/Clerical	50.00	HR	0.00	97.18	0.00	$4,859	
Draftsman/CADD	46.00	HR	0.00	127.43	0.00	$5,862	
SUBTOTAL						**$174,160**	
Groundwater Monitoring (Years 3, 4 and 5)							16 wells sampled semi-annually
Disposable Materials per Sample	38.00	EA	12.14	0.00	0.00	$461	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	38.00	EA	10.84	0.00	0.00	$412	per sampling event
Nylon Tubing, 1/4" Outside Diameter	812.50	LF	0.63	0.00	0.00	$512	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	2.00	WK	95.45	0.00	0.00	$191	
Flow Through Monitor, Weekly Rental	2.00	WK	323.68	0.00	0.00	$647	
Water Quality Parameter Testing Device	2.00	WK	344.33	0.00	0.00	$689	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	38.00	EA	47.87	0.00	0.00	$1,819	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	38.00	EA	37.11	0.00	0.00	$1,410	
Volatile Organic Analysis (EPA 624), Water Analysis	38.00	EA	296.90	0.00	0.00	$11,282	
Sulfate (EPA 300.0), Water Analysis	38.00	EA	27.94	0.00	0.00	$1,062	
Sulfide (EPA 376.1), Water Analysis	38.00	EA	40.89	0.00	0.00	$1,554	
Ferrous Iron (S.M. 3500 Fe - D)	38.00	EA	129.55	0.00	0.00	$4,923	
4" Submersible Pump Rental, Week	2.00	WK	329.12	0.00	0.00	$658	
Car or Van Mileage Charge	450.00	MI	0.52	0.00	0.00	$234	
Project Manager	6.00	HR	0.00	307.79	0.00	$1,847	
Project Engineer	15.00	HR	0.00	196.52	0.00	$2,948	
Project Scientist	205.00	HR	0.00	186.88	0.00	$38,310	
Staff Scientist	40.00	HR	0.00	153.23	0.00	$6,129	
Field Technician	85.00	HR	0.00	123.28	0.00	$10,479	
Word Processing/Clerical	25.00	HR	0.00	97.18	0.00	$2,430	
Draftsman/CADD	23.00	HR	0.00	127.43	0.00	$2,931	
SUBTOTAL						**$90,927**	
SUBTOTAL (Years 1 and 2) including 25% contingency						**$217,700**	
SUBTOTAL (Years 3, 4 and 5) including 25% contingency						**$113,659**	

PERIODIC COSTS[a]:	Year	Quantity	Unit of Measure	Labor Unit Cost	Extended Cost
Well Abandonment	5	16.00	EA	837.00	$13,392
Close-out Report	5	1.00	EA	47928.91	$47,929
Contingency		25%			$15,330
SUBTOTAL					**$76,651**

PRESENT VALUE ANALYSES:

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factord,e	Present Value	Notes
Capital Cost	0	$1,069,683	$1,069,683	1.0000	$1,069,683	
Annual O&M	1-2	$435,400	$217,700	1.9387	$422,059	Years 1 and 2 monitoring
Annual O&M	3-5	$340,978	$113,659	2.8783	$327,143	Years 3 through 5 monitoring
Periodic Cost	5	$76,651	$76,651	0.9013	$69,086	Well abandonment, Close-out report
		$1,846,061			**$1,887,971**	

TOTAL PRESENT VALUE OF ALTERNATIVE #=3A $\boxed{\$1,887,971}$

Notes:
a Costs provided by RACER 2004
b Vendor quote from Dave Reilly at Regenesis, (949) 366-8001 x 125 on December 13, 2004
c Vendor quote from Derrik M Sandberg at ResonantSonic International on December 13, 2004, (530) 668-2424
d Discount factor = $\frac{1}{(1+i)^t}$ where i = 0.021 and t = year (i.e., the present value of the dollar paid in year t at 2.1%)
e Multi-year discount factor = $\frac{(1+i)^n - 1}{i(1+i)^n}$ where i = 0.021 for a 5 year technology, t = year, and n = total number of years (i.e., the present value of the dollar paid per year from year 1 to year n at 2.1%)

TABLE B-4 ALTERNATIVE 3B ENHANCED BIOREMEDAITION USING HRC OF MAIN PORTION OF PLUME TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Addition of hydrogen release compounds to contaminated groundwater (main portion of plume) in two injections over three years. Quarterly groundwater monitoring during first two years of active treatment, semi-annual monitoring for three years, annual monitoring for 15 years. Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
CAPITAL COSTS:							
Vadose Zone							
Soil Vapor Extraction							
Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	2,543.68	3,458.87	$6,003	
Organic Vapor Analyzer Rental, per Day	1.00	DAY	176.27	0.00	0.00	$176	
1 HP, 230V, 98 SCFM, Vapor Recovery System	1.00	EA	5,686.86	1,302.80	0.00	$6,990	
Decontaminate Rig, Augers, Screen (Rental Equipment)	1.00	DAY	173.49	0.00	0.00	$173	
Field Technician	16.00	HR	0.00	127.93	0.00	$2,047	
2" PVC, Schedule 40, Well Casing	5.00	LF	1.73	8.48	11.53	$109	
2" PVC, Schedule 40, Well Screen	5.00	LF	4.00	10.94	14.87	$149	
2" PVC, Well Plug	1.00	EA	8.43	12.72	17.29	$38	
Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	11.00	LF	0.00	23.25	31.62	$604	
2" Screen, Filter Pack	7.00	LF	4.50	7.21	9.80	$151	
2" Well, Portland Cement Grout	2.00	LF	1.67	0.00	0.00	$3	
2" Well, Bentonite Seal	1.00	EA	13.37	28.62	38.91	$81	
2" PVC, Schedule 80, Connection Piping	16.50	LF	1.28	9.22	0.00	$173	
2" PVC, Schedule 80, Tee	1.00	EA	18.41	0.00	0.00	$18	
2" PVC, Schedule 80, 90 Degree, Elbow	1.00	EA	5.01	0.00	0.00	$5	
2" PVC, Sch 80, Ball Valve	1.00	EA	128.70	0.00	0.00	$129	
Pressure Gauge	1.00	EA	101.59	134.63	0.00	$236	
Carbon Adsorption GGas)							
8" Structural Slab on Grade	15.00	SF	5.92	8.92	0.60	$232	
Saturation Indicator	1.00	EA	75.13	0.00	0.00	$75	
Monitoring Port with Gas Monitor	2.00	EA	1.63	46.32	0.00	$96	
50 CFM, 110 Lb Fill, Closed Upflow, 7.0" Pressure Drop	1.00	EA	726.30	249.38	0.00	$976	
50 CFM, 7" Pressure, 3/4 HP, Blower System	1.00	EA	1,302.34	433.24	0.00	$1,736 $0	
Pressure Gauge	2.00	EA	101.59	134.63	0.00	$472	
Soil Vapor Sampling							
Monitoring Gas Vents	4.00	EA	0.00	34.38	0.00	$138	
Tentative ID Compunds, GC/MS, Air (30/5041/8260B - TO-14), Air Analysis	5.00	EA	236.47	0.00	0.00	$1,182	
SUBTOTAL						**$21,991**	
Installation of Groundwater Monitoring Wells (12 wells to 27 ft bgs)[a]							12 new wells
Organic Vapor Analyzer Rental, per Day	5.00	DAY	165.99	0.00	0.00	$830	
Direct Push Rig, Truck Mounted, Non Hydraulic, Includes Labor, Sampling, Decontamination	5.00	DAY	248.99	0.00	0.00	$1,245	
Mobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Demobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Volatile Organic Analysis (SW 5035/SW 8260B), Soil Analysis	24.00	EA	296.90	0.00	0.00	$7,126	
Field Technician	120.00	HR	0.00	123.28	0.00	$14,794	
2" PVC, Schedule 40, Well Casing	204.00	LF	1.63	7.80	9.52	$3,866	
2" PVC, Schedule 40, Well Screen	120.00	LF	3.77	10.06	12.29	$3,134	
2" PVC, Well Plug	12.00	EA	7.94	11.70	14.29	$407	
Split Spoon Sampling	72.00	LF	0.00	33.43	40.82	$5,346	
Furnish 55 Gallon Drum for Drill Cuttings & Development Water	18.00	EA	114.10	0.00	0.00	$2,054	
2" Screen, Filter Pack	144.00	LF	4.23	6.63	8.10	$2,730	
2" Well, Portland Cement Grout	168.00	LF	1.58	0.00	0.00	$265	
2" Well, Bentonite Seal	12.00	EA	12.59	26.33	32.14	$853	
SUBTOTAL						**$44,310**	
HRC Injection and Materials[b]							
Pilot Test							
Work Plan						$10,000	
HRC material	420.00	LB	5.00	0.00	0.00	$2,100	
Shipping and Sales Tax	420.00	LB	0.45	0.00	0.00	$187	
Mobilization[c]	1.00	LS	0.00	0.00	0.00	$600	
Drill Rig[c]	1.00	DAY	0.00	0.00	1750.00	$1,750	
Injection Pump[c]	1.00	DAY	0.00	0.00	325.00	$325	
Borehole Abandonment[c]	75.00	LF	0.00	0.00	1.00	$75	Upper 5 feet will be abandoned
Steam Cleaner[c]	1.00	DAY	0.00	0.00	95.00	$95	
Staff Scientist[a]	78.00	HR	0.00	140.14	0.00	$10,931	

TABLE B-4 ALTERNATIVE 3B ENHANCED BIOREMEDAITION USING HRC OF MAIN PORTION OF PLUME TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Addition of hydrogen release compounds to contaminated groundwater (main portion of plume) in two injections over three years. Quarterly groundwater monitoring during first two years of active treatment, semi-annual monitoring for three years, annual monitoring for 15 years. Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
Pilot Test Groundwater Monitoring[a]							3 wells sampled quarterly
RSK175 analysis for dissolved gases	14.00	EA	97.83	0.00	0.00	$1,370	
Disposable Materials per Sample	14.00	EA	10.76	0.00	0.00	$151	
Decontamination Materials per Sample	14.00	EA	9.68	0.00	0.00	$136	
Nylon Tubing, 1/4" Outside Diameter	325.00	LF	0.56	0.00	0.00	$182	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	14.00	WK	88.82	0.00	0.00	$1,243	
Flow Through Monitor, Weekly Rental	4.00	WK	301.20	0.00	0.00	$1,205	
Water Quality Parameter Testing Device	4.00	WK	307.24	0.00	0.00	$1,229	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	14.00	EA	55.69	0.00	0.00	$780	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	14.00	EA	38.58	0.00	0.00	$540	
Volatile Organic Analysis (EPA 624), Water Analysis	14.00	EA	276.27	0.00	0.00	$3,868	
Chloride (EPA 300), Water Analysis	14.00	EA	28.41	0.00	0.00	$398	
Sulfate (EPA 300.0), Water Analysis	14.00	EA	28.94	0.00	0.00	$405	
Sulfide (EPA 376.1), Water Analysis	14.00	EA	49.10	0.00	0.00	$687	
Ferrous Iron (S.M. 3500 Fe - D)	14.00	EA	146.31	0.00	0.00	$2,048	
55 Gallon 17C Closed Head Steel Drum	4.00	EA	91.19	0.00	0.00	$365	
4" Submersible Pump Rental, Day	4.00	DAY	103.31	0.00	0.00	$413	
Car or Van Mileage Charge	400.00	MI	0.48	0.00	0.00	$192	
Project Scientist	63.00	HR	0.00	146.81	0.00	$9,249	
Field Technician	71.00	HR	0.00	97.98	0.00	$6,957	
Word Processing/Clerical	7.00	HR	0.00	81.20	0.00	$568	
Draftsman/CADD	7.00	HR	0.00	125.83	0.00	$881	
Primary Treatment							
HRC material	6600.00	LB	5.75	0.00	0.00	$37,950	
Shipping and Sales Tax	6600.00	LB	0.64	0.00	0.00	$4,216	
Mobilization[c]	1.00	LS	0.00	0.00	0.00	$600	
Drill Rig[c]	10.00	DAY	0.00	0.00	1750.00	$17,500	Drilling 240 feet per day
Injection Pump[c]	10.00	DAY	0.00	0.00	325.00	$3,250	
Borehole Abandonment[c]	1200.00	LF	0.00	0.00	1.00	$1,200	Only upper 15 feet will be abandoned
Steam Cleaner[c]	10.00	DAY	0.00	0.00	95.00	$950	
Hand Auger[c]	1.00	DAY	0.00	0.00	750.00	$750	Assumes 8 cores per day
Local Travel for Hand Auger Crew[c]	1.00	DAY	0.00	150.00	0.00	$150	
Concrete Coring[c]	1.00	DAY	0.00	0.00	1100.00	$1,100	Assumes 8 cores per day
Local Travel for Concrete Coring Crew[c]	1.00	DAY	0.00	150.00	0.00	$150	
Car or Van Mileage Charge[a]	6000.00	MI	0.48	0.00	0.00	$2,880	
Follow up Treatment (50% Retreat, If Necessary)							
HRC material	3300.00	LB	5.75	0.00	0.00	$18,975	
Shipping and Sales Tax	3300.00	LB	0.64	0.00	0.00	$2,108	
Mobilization[c]	1.00	LS	0.00	0.00	0.00	$600	
Drill Rig[c]	5.00	DAY	0.00	0.00	1750.00	$8,750	Drilling 200 feet per day
Injection Pump[c]	5.00	DAY	0.00	0.00	325.00	$1,625	
Borehole Abandonment[c]	600.00	LF	0.00	0.00	1.00	$600	Only upper 15 feet will be abandoned
Steam Cleaner[c]	5.00	DAY	0.00	0.00	95.00	$475	
Hand Auger[c]	1.00	DAY	0.00	0.00	750.00	$750	Assumes 8 cores per day
Local Travel for Hand Auger Crew[c]	1.00	DAY	0.00	150.00	0.00	$150	
Concrete Coring[c]	1.00	DAY	0.00	0.00	1100.00	$1,100	Assumes 8 cores per day
Local Travel for Concrete Coring Crew[c]	1500.00	DAY	0.00	150.00	0.00	$225,000	
Car or Van Mileage Charge[a]	3000.00	MI	0.48	0.00	0.00	$1,440	
SUBTOTAL all HRC Material and Injections						**$391,198**	
SUBTOTAL						$457,499	
Contingency		25%				$114,375	10% scope + 15% bid
SUBTOTAL						**$571,873**	
Professional Labor Management[a]							
Design and Work Plan		8.00%				$45,750	
Project Management Labor Cost		2.50%				$14,297	
Planning Documents Labor Cost		2.50%				$14,297	
Construction Oversight Labor Cost		2.75%				$15,727	
Reporting Labor Cost		0.35%				$2,002	
As-Built Drawings Labor Cost		0.35%				$2,002	
Public Notice Labor Cost		0.08%				$457	
Site Closure Activities Labor Cost		0.00%				$0	
Permitting Labor Cost		5.00%				$28,594	
SUBTOTAL						**$123,124**	
TOTAL CAPITAL COST IN 2004 DOLLARS						**$694,998**	

TABLE B-4 ALTERNATIVE 3B ENHANCED BIOREMEDAITION USING HRC OF MAIN PORTION OF PLUME TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Addition of hydrogen release compounds to contaminated groundwater (main portion of plume) in two injections over three years. Quarterly groundwater monitoring during first two years of active treatment, semi-annual monitoring for three years, annual monitoring for 15 years. Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
OPERATIONS AND MAINTENANCE COSTS:							
Groundwater Monitoring (Years 1 and 2)[a]							16 wells samples quarterly
Disposable Materials per Sample	76.00	EA	12.14	0.00	0.00	$923	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	76.00	EA	10.84	0.00	0.00	$824	per sampling event
Nylon Tubing, 1/4" Outside Diameter	1625.00	LF	0.63	0.00	0.00	$1,024	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	4.00	WK	95.45	0.00	0.00	$382	
Flow Through Monitor, Weekly Rental	4.00	WK	323.68	0.00	0.00	$1,295	
Water Quality Parameter Testing Device	4.00	WK	344.33	0.00	0.00	$1,377	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	76.00	EA	47.87	0.00	0.00	$3,638	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	76.00	EA	37.11	0.00	0.00	$2,820	
Volatile Organic Analysis (EPA 624), Water Analysis	76.00	EA	296.90	0.00	0.00	$22,564	
Sulfate (EPA 300.0), Water Analysis	76.00	EA	27.94	0.00	0.00	$2,123	
Sulfide (EPA 376.1), Water Analysis	76.00	EA	40.89	0.00	0.00	$3,108	
Ferrous Iron (S.M. 3500 Fe - D)	76.00	EA	129.55	0.00	0.00	$9,846	
4" Submersible Pump Rental, Week	4.00	WK	329.12	0.00	0.00	$1,316	
Car or Van Mileage Charge	900.00	MI	0.52	0.00	0.00	$468	
Project Manager	4.00	HR	0.00	307.79	0.00	$1,231	
Project Engineer	30.00	HR	0.00	196.52	0.00	$5,896	
Project Scientist	382.00	HR	0.00	186.88	0.00	$71,388	
Staff Scientist	80.00	HR	0.00	153.23	0.00	$12,258	
Field Technician	170.00	HR	0.00	123.28	0.00	$20,958	
Word Processing/Clerical	50.00	HR	0.00	97.18	0.00	$4,859	
Draftsman/CADD	46.00	HR	0.00	127.43	0.00	$5,862	
SUBTOTAL						**$174,160**	
Groundwater Monitoring (Years 3, 4 and 5)[a]							16 wells sampled semi-annually
Disposable Materials per Sample	38.00	EA	12.14	0.00	0.00	$461	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	38.00	EA	10.84	0.00	0.00	$412	per sampling event
Nylon Tubing, 1/4" Outside Diameter	812.50	LF	0.63	0.00	0.00	$512	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	2.00	WK	95.45	0.00	0.00	$191	
Flow Through Monitor, Weekly Rental	2.00	WK	323.68	0.00	0.00	$647	
Water Quality Parameter Testing Device	2.00	WK	344.33	0.00	0.00	$689	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	38.00	EA	47.87	0.00	0.00	$1,819	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	38.00	EA	37.11	0.00	0.00	$1,410	
Volatile Organic Analysis (EPA 624), Water Analysis	38.00	EA	296.90	0.00	0.00	$11,282	
Sulfate (EPA 300.0), Water Analysis	38.00	EA	27.94	0.00	0.00	$1,062	
Sulfide (EPA 376.1), Water Analysis	38.00	EA	40.89	0.00	0.00	$1,554	
Ferrous Iron (S.M. 3500 Fe - D)	38.00	EA	129.55	0.00	0.00	$4,923	
4" Submersible Pump Rental, Week	2.00	WK	329.12	0.00	0.00	$658	
Car or Van Mileage Charge	450.00	MI	0.52	0.00	0.00	$234	
Project Manager	4.00	HR	0.00	307.79	0.00	$1,231	
Project Engineer	15.00	HR	0.00	196.52	0.00	$2,948	
Project Scientist	205.00	HR	0.00	186.88	0.00	$38,310	
Staff Scientist	40.00	HR	0.00	153.23	0.00	$6,129	
Field Technician	85.00	HR	0.00	123.28	0.00	$10,479	
Word Processing/Clerical	25.00	HR	0.00	97.18	0.00	$2,430	
Draftsman/CADD	23.00	HR	0.00	127.43	0.00	$2,931	
SUBTOTAL						**$90,312**	

TABLE B-4 ALTERNATIVE 3B ENHANCED BIOREMEDAITION USING HRC OF MAIN PORTION OF PLUME TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Addition of hydrogen release compounds to contaminated groundwater (main portion of plume) in two injections over three years. Quarterly groundwater monitoring during first two years of active treatment, semi-annual monitoring for three years, annual monitoring for 15 years. Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Notes
Groundwater Monitoring (Years 6 through 20)[a]							16 wells sampled annually
Disposable Materials per Sample	19.00	EA	12.14	0.00	0.00	$231	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	19.00	EA	10.84	0.00	0.00	$206	per sampling event
Nylon Tubing, 1/4" Outside Diameter	406.25	LF	0.63	0.00	0.00	$256	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	1.00	WK	95.45	0.00	0.00	$95	
Flow Through Monitor, Weekly Rental	1.00	WK	323.68	0.00	0.00	$324	
Water Quality Parameter Testing Device	1.00	WK	344.33	0.00	0.00	$344	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	19.00	EA	47.87	0.00	0.00	$910	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	19.00	EA	37.11	0.00	0.00	$705	
Volatile Organic Analysis (EPA 624), Water Analysis	19.00	EA	296.90	0.00	0.00	$5,641	
Sulfate (EPA 300.0), Water Analysis	19.00	EA	27.94	0.00	0.00	$531	
Sulfide (EPA 376.1), Water Analysis	19.00	EA	40.89	0.00	0.00	$777	
Ferrous Iron (S.M. 3500 Fe - D)	19.00	EA	129.55	0.00	0.00	$2,461	
4" Submersible Pump Rental, Week	1.00	WK	329.12	0.00	0.00	$329	
Car or Van Mileage Charge	225.00	MI	0.52	0.00	0.00	$117	
Project Manager	6.00	HR	0.00	307.79	0.00	$1,847	
Project Engineer	8.00	HR	0.00	196.52	0.00	$1,572	
Project Scientist	115.00	HR	0.00	186.88	0.00	$21,491	
Staff Scientist	20.00	HR	0.00	153.23	0.00	$3,065	
Field Technician	45.00	HR	0.00	123.28	0.00	$5,548	
Word Processing/Clerical	15.00	HR	0.00	97.18	0.00	$1,458	
Draftsman/CADD	15.00	HR	0.00	127.43	0.00	$1,911	
SUBTOTAL						**$49,819**	
SUBTOTAL (Years 1 and 2) including 25% contingency						**$217,700**	
SUBTOTAL (Years 3, 4 and 5) including 25% contingency						**$112,890**	
SUBTOTAL (Years 6 through 20) including 25% contingency						**$62,273**	

PERIODIC COSTS:	**Year**	Quantity	Unit	Labor Unit Cost	Extended Cost	Notes
Five Year review Report	5-15	3.00	EA	20710.05	$62,130	End of years 5, 10, 15
Contingency		0.25			$15,533	10% scope + 15% bid
SUBTOTAL					**$77,663**	
Well Abandonment	20	16.00	EA	837.00	$13,392	
Close-out Report	20	1.00	EA	47928.91	$47,929	
Contingency		25%			$15,330	
SUBTOTAL					**$76,651**	

PRESENT VALUE ANALYSES:

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factord,e	Present Value	Notes
Capital Cost	0	$694,998	$694,998	1.0000	$694,998	
Annual O&M	1-2	$435,400	$217,700	1.9079	$415,358	Years 1 nd 2 monitoring
Annual O&M	3-5	$338,670	$112,890	2.8178	$318,098	Years 3 through 5 monitoring
Annual O&M	6-20	$934,097	$62,273	11.0833	$690,193	Years 6 through 20 monitoring
Periodic Cost	5-15	$77,663	$25,888	2.3534	$60,924	Five-year reviews
Periodic Cost	20	$76,651	$76,651	0.5326	$40,825	Well abandonment, close-out report
		$2,557,479			**$2,220,395**	

TOTAL PRESENT VALUE OF ALTERNATIVE 3B $\boxed{\$2,220,395}$

Notes:
a Costs provided by RACER 2004
b Vendor quote from Dave Reilly at Regenesis, (949) 366-8001 x 125 on December 13, 2004
c Vendor quote from Derrik M Sandberg at ResonantSonic International on December 13, 2004, (530) 668-2424
d Discount factor = $\frac{1}{(1+i)^t}$ where i = 0.032 and t = year (i.e., the present value of the dollar paid in year t at 3.2)
e Multi-year discount factor = $\frac{(1+i)^n - 1}{i(1+i)^n}$ where i = 0.032 for a 20 year technology, t = year, and n = total number of years (i.e., the present value of the dollar paid per year from year 1 to year n at 3.2%)

TABLE B-5 ALTERNATIVE 4 PUMP AND TREAT WITH AIR STRIPPING TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Pump and treat of contaminated groundwater (entire plume) by air stripping processes. Quarterly groundwater montitoring during first two years of active treatment. Semiannul groundwater sampling for 3 years, annual sampling for 15 years.Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Costa	Notes
CAPITAL COSTS[a]:							
Start-up Costs							
Other Direct Costs	1.00	LS	25449.05	31079.37	12837.13	$69,366	
Vadose Zone							
Soil Vapor Extraction							
Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	2,543.68	3,458.87	$6,003	
Organic Vapor Analyzer Rental, per Day	1.00	DAY	176.27	0.00	0.00	$176	
1 HP, 230V, 98 SCFM, Vapor Recovery System	1.00	EA	5,686.86	1,302.80	0.00	$6,990	
Decontaminate Rig, Augers, Screen (Rental Equipment)	1.00	DAY	173.49	0.00	0.00	$173	
Field Technician	16.00	HR	0.00	127.93	0.00	$2,047	
2" PVC, Schedule 40, Well Casing	5.00	LF	1.73	8.48	11.53	$109	
2" PVC, Schedule 40, Well Screen	5.00	LF	4.00	10.94	14.87	$149	
2" PVC, Well Plug	1.00	EA	8.43	12.72	17.29	$38	
Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	11.00	LF	0.00	23.25	31.62	$604	
2" Screen, Filter Pack	7.00	LF	4.50	7.21	9.80	$151	
2" Well, Portland Cement Grout	2.00	LF	1.67	0.00	0.00	$3	
2" Well, Bentonite Seal	1.00	EA	13.37	28.62	38.91	$81	
2" PVC, Schedule 80, Connection Piping	16.50	LF	1.28	9.22	0.00	$173	
2" PVC, Schedule 80, Tee	1.00	EA	18.41	0.00	0.00	$18	
2" PVC, Schedule 80, 90 Degree, Elbow	1.00	EA	5.01	0.00	0.00	$5	
2" PVC, Sch 80, Ball Valve	1.00	EA	128.70	0.00	0.00	$129	
Pressure Gauge	1.00	EA	101.59	134.63	0.00	$236	
Carbon Adsorption GGas)							
8" Structural Slab on Grade	15.00	SF	5.92	8.92	0.60	$232	
Saturation Indicator	1.00	EA	75.13	0.00	0.00	$75	
Monitoring Port with Gas Monitor	2.00	EA	1.63	46.32	0.00	$96	
50 CFM, 110 Lb Fill, Closed Upflow, 7.0" Pressure Drop	1.00	EA	726.30	249.38	0.00	$976	
50 CFM, 7" Pressure, 3/4 HP, Blower System	1.00	EA	1,302.34	433.24	0.00	$1,736 $0	
Pressure Gauge	2.00	EA	101.59	134.63	0.00	$472	
Soil Vapor Sampling							
Monitoring Gas Vents	4.00	EA	0.00	34.38	0.00	$138	
Tentative ID Compunds, GC/MS, Air (30/5041/8260B - TO-14), Air Analysis	5.00	EA	236.47	0.00	0.00	$1,182	
SUBTOTAL						**$21,991**	
Installation of Groundwater Monitoring Wells (12 wells to 27 ft bgs)							12 new wells
Organic Vapor Analyzer Rental, per Day	5.00	DAY	165.99	0.00	0.00	$830	
Direct Push Rig, Truck Mounted, Non Hydraulic, Includes Labor, Sampling, Decontamination	5.00	DAY	248.99	0.00	0.00	$1,245	
Mobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Demobilize Direct Push Rig and Crew	1.00	DAY	829.96	0.00	0.00	$830	
Volatile Organic Analysis (SW 5035/SW 8260B), Soil Analysis	24.00	EA	296.90	0.00	0.00	$7,126	
Field Technician	120.00	HR	0.00	123.28	0.00	$14,794	
2" PVC, Schedule 40, Well Casing	204.00	LF	1.63	7.80	9.52	$3,866	
2" PVC, Schedule 40, Well Screen	120.00	LF	3.77	10.06	12.29	$3,134	
2" PVC, Well Plug	12.00	EA	7.94	11.70	14.29	$407	
Split Spoon Sampling	72.00	LF	0.00	33.43	40.82	$5,346	
Furnish 55 Gallon Drum for Drill Cuttings & Development Water	18.00	EA	114.10	0.00	0.00	$2,054	
2" Screen, Filter Pack	144.00	LF	4.23	6.63	8.10	$2,730	
2" Well, Portland Cement Grout	168.00	LF	1.58	0.00	0.00	$265	
2" Well, Bentonite Seal	12.00	EA	12.59	26.33	32.14	$853	
SUBTOTAL						**$44,310**	

TABLE B-5 ALTERNATIVE 4 PUMP AND TREAT WITH AIR STRIPPING TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Pump and treat of contaminated groundwater (entire plume) by air stripping processes. Quarterly groundwater montitoring during first two years of active treatment. Semiannul groundwater sampling for 3 years, annual sampling for 15 years.Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Costa	Notes
Groundwater Extraction Wells							
Demolish Bituminous Pavement with Air Equipment	3.20	CY	0.00	84.62	11.48	$308	
Organic Vapor Analyzer Rental, per Day	36.00	DAY	165.99	0.00	0.00	$5,976	
Direct Push Rig, Truck Mounted, Non Hydraulic, Includes Labor, Sampling, Decontamination	36.00	DAY	248.99	0.00	0.00	$8,964	
Mobilize Direct Push Rig and Crew	36.00	DAY	829.96	0.00	0.00	$29,879	
Demobilize Direct Push Rig and Crew	36.00	DAY	829.96	0.00	0.00	$29,879	
5,000 Gallon Single-wall Steel Aboveground Tank	1.00	EA	6801.61	3585.30	250.83	$10,638	
Field Technician	91.00	HR	0.00	123.28	0.00	$11,218	
6" PVC, Schedule 40, Well Casing	240.00	LF	5.69	11.23	13.72	$7,354	
2" Pitless Adapter	16.00	EA	274.68	0.00	22.92	$4,762	
6" PVC, Schedule 40, Well Screen	144.00	LF	12.95	18.72	22.86	$7,852	
6" PVC, Well Plug	16.00	EA	87.22	29.25	35.72	$2,435	
4" Submersible Pump, 0.3-7 GPM, Head <=140', 1/3 hp, w/ controls	16.00	EA	2723.92	0.00	0.00	$43,583	
Split Spoon Sample, 2" x 24", During Drilling	39.00	EA	59.25	0.00	0.00	$2,311	
Furnish 55 Gallon Drum for Drill Cuttings & Development Water	54.00	EA	114.10	0.00	0.00	$6,161	
Well Development Equipment Rental (weekly)	16.00	WK	344.33	0.00	0.00	$5,509	
6" Screen, Filter Pack	144.00	LF	10.84	16.97	20.72	$6,988	
6" Well, Portland Cement Grout	11.00	LF	13.41	0.00	0.00	$148	
6" Well, Bentonite Seal	16.00	EA	50.34	105.31	128.58	$4,548	
Restricted Area, Well Protection (with 4 Posts & Explosionproof Receptacle)	16.00	EA	772.45	870.86	3.47	$26,348	
1" PVC, Schedule 80, Connection Piping	2000.00	LF	0.53	6.13	0.00	$13,320	
SUBTOTAL						**$430,146**	
Overhead Electrical Distribution							
1/0 ACSR Conductor	1908.00	LF	0.31	1.61	0.07	$3,797	
1/C #2 Aluminum, Bare, Wire	796.00	LF	0.23	1.55	0.07	$1,473	
40' Class 3 Treated Power Pole	4.00	EA	458.57	907.33	61.07	$5,708	
Straight-line Structure, 5 KV Pole Top	2.00	EA	156.66	817.63	55.03	$2,059	
Terminal Structure, 5 KV Pole Top	2.00	EA	1770.67	3102.52	208.81	$10,164	
5 KV, 3/0, Shielded Cable, Copper	120.00	LF	3.85	3.99	0.27	$973	
5 KV, 1/0 to 4/0 Conductor, Terminations & Splicing	6.00	EA	683.44	619.29	0.00	$7,816	
4" Rigid Steel Conduit	40.00	LF	13.54	24.95	0.00	$1,540	
SUBTOTAL						**$33,529**	
Air Stripping							
6" Structural Slab on Grade	70.00	SF	3.77	6.44	0.23	$731	
2", Class 200, PVC Piping	100.00	LF	0.62	11.88	0.57	$1,307	
550 Gallon Horizontal Plastic Sump with 4" NPT Connection	1.00	EA	2062.72	692.61	0.00	$2,755	
10 Gallon Bypass Chemical Shot Feeder, Floor Mount, 150 Lb ASME	1.00	EA	2108.50	2079.01	0.00	$4,188	
Install Air Stripper Tower, 1' - 3' Diameter, 13' - 20' High	1.00	EA	0.00	11153.36	780.31	$11,934	
Internal Parts for Air Stripper, >= 20' High, per Foot of Tower Diameter	2.00	FT	4884.50	0.00	0.00	$9,769	
1" - 3.5" Packing for Air Stripper Tower	32.00	CF	24.57	0.00	0.00	$786	
Electrical Controls for Air Stripper	1.00	EA	6474.33	4419.13	137.96	$11,031	
2.0' Diameter x Height, Prefabricated, Fiberglass Reinforced Plastic, Air Stripper Column/Shell Only	15.00	FT	510.99	0.00	0.00	$7,665	
High Sump Level Switch for Avoiding Overflow	1.00	EA	314.45	452.31	0.00	$767	
50 GPM, 1.5 HP, Transfer Pump with Motor, Valves, Piping	2.00	EA	3961.44	2767.83	0.00	$13,459	
500 CFM, 9" Pressure, 2 HP, Blower System	1.00	EA	1759.36	616.74	0.00	$2,376	
SUBTOTAL						**$66,767**	
Carbon Adsorbtion (liquid)							
8" Structural Slab on Grade	35.00	SF	5.57	8.20	0.50	$499	
50 GPM, 880 Lb Fill, High-density Polyethylene-lined Steel Permanent	2.00	EA	8961.90	1088.64	153.29	$20,408	
50 GPM, 1.5 HP, Transfer Pump with Motor, Valves, Piping	1.00	EA	3961.44	2767.83	0.00	$6,729	
SUBTOTAL						**$27,636**	
Discharge to Publicly Owned Treatment Works							
Medium Brush, Medium Trees, Clear, Grub, Haul	1.00	ACRE	0.00	10222.02	3939.59	$14,162	
Cat 225, 1.5 CY, Soil/Sand, Trenching	112.00	CY	0.00	1.12	0.72	$206	
950, 3.00 CY, Backfill with Excavated Material	110.00	CY	0.00	1.41	0.89	$253	
Seeding, Vegetative Cover	1.00	ACRE	4719.13	209.36	72.45	$5,001	
6" PVC Pipe Sanitary	200.00	LF	3.43	11.92	2.50	$3,570	
Class II Industrial User Connection Fee	1.00	EA	4300.00	0.00	0.00	$4,300	
SUBTOTAL						**$27,492**	

TABLE B-5 ALTERNATIVE 4 PUMP AND TREAT WITH AIR STRIPPING TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Pump and treat of contaminated groundwater (entire plume) by air stripping processes. Quarterly groundwater montitoring during first two years of active treatment. Semiannul groundwater sampling for 3 years, annual sampling for 15 years.Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Costa	Notes
Residual Waste Management (Soil)							
T & D of Debris to a Class I Facility, Assuming RCRA Stabilization for Lead	0.00	TON	0.00	192.91	0.00	$0	
T & D of Debris to a Class I Facility, Assuming Cal-Haz Material	0.00	TON	0.00	80.21	0.00	$0	
T & D of Debris to a Class II Facility	263.00	TON	0.00	55.20	0.00	$14,518	
TCLP (RCRA) (EPA 1311), Soil Analysis	2.00	EA	821.93	0.00	0.00	$1,644	
SUBTOTAL						**$16,161**	
SUBTOTAL						$737,398	
Contingency		25%				$184,350	10% scope + 15% bid
SUBTOTAL						$921,748	
Professional Labor Management[a]							
Design and Work Plan		8.00%				$73,740	
Project Management Labor Cost		2.50%				$23,044	
Planning Documents Labor Cost		2.50%				$23,044	
Construction Oversight Labor Cost		2.75%				$25,348	
Reporting Labor Cost		0.35%				$3,226	
As-Built Drawings Labor Cost		0.35%				$3,226	
Public Notice Labor Cost		0.08%				$737	
Site Closure Activities Labor Cost		0.00%				$0	
Permitting Labor Cost		5.00%				$46,087	
SUBTOTAL						**$124,712**	
TOTAL CAPITAL COST IN 2004 DOLLARS						**$1,046,460**	
OPERATIONS AND MAINTENANCE COSTS[a]:							
Treatment Train Miscellaneous							
Disposable Gloves (Latex)	209.00	PAIR	0.25	0.00	0.00	$52	
Disposable Coveralls (Tyvek)	209.00	EA	5.11	0.00	0.00	$1,068	
Non Haz Drummed Site Waste - Load, Transp, & Landfill Disp (55-Gal Drums)	6.00	EA	234.77	0.00	0.00	$1,409	
DOT Steel Drum, 55 Gallon	6.00	EA	88.63	0.00	0.00	$532	
Annual Maintenance Materials and Labor	1.00	LS	3123.18	3123.18	1561.59	$7,808	
SUBTOTAL						**$10,869**	
Groundwater Extraction Wells							
Staff Engineer	51.00	HR	0.00	60.85	0.00	$3,103	
Field Technician	255.00	HR	0.00	40.83	0.00	$10,412	
Electrical Charge	5866.00	KWH	0.08	0.00	0.00	$469	
SUBTOTAL						**$13,984**	
Air Stripping							
Staff Engineer	30.00	HR	0.00	60.85	0.00	$1,826	
Field Technician	149.00	HR	0.00	40.83	0.00	$6,084	
Electrical Charge	34667.00	KWH	0.08	0.00	0.00	$2,773	
SUBTOTAL						**$10,683**	
Carbon Adsorption							
Coal-based, 4 mm Pellet, for Solvent Recovery 2,000 - 10,000 Lb	1819.00	LB	1.21	0.00	0.00	$2,201	
Removal, Transport, Regeneration of Spent Carbon, < 2K lb	1819.00	LB	0.71	0.00	0.00	$1,291	
Staff Engineer	54.00	HR	0.00	60.85	0.00	$3,286	
Field Technician	268.00	HR	0.00	40.83	0.00	$10,942	
Electrical Charge	31843.00	KWH	0.08	0.00	0.00	$2,547	
SUBTOTAL						**$20,268**	
Discharge to Publicly Owned Treatment Works							
Wastewater Disposal Fee	21024.00	KGAL	20.00	0.00	0.00	$420,480	
Staff Engineer	5.00	HR	0.00	143.89	0.00	$719	
Field Technician	24.00	HR	0.00	97.98	0.00	$2,352	
Electrical Charge	6560.00	KWH	0.09	0.00	0.00	$590	
Class II Industrial User Connection Fee	1.00	EA	4300.00	0.00	0.00	$4,300	
SUBTOTAL						**$428,441**	
SUBTOTAL						$484,245	
Runtime Percent Cost Adjustment	97%					$469,718	
Contingency	25%					$121,061	10% scope + 15% bid
SUBTOTAL						**$590,779**	

TABLE B-5 ALTERNATIVE 4 PUMP AND TREAT WITH AIR STRIPPING TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Pump and treat of contaminated groundwater (entire plume) by air stripping processes. Quarterly groundwater montitoring during first two years of active treatment. Semiannul groundwater sampling for 3 years, annual sampling for 15 years.Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Costa	Notes
Groundwater Monitoring (Years 1 and 2)							16 wells sampled quarterly
Disposable Materials per Sample	76.00	EA	12.14	0.00	0.00	$923	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	76.00	EA	10.84	0.00	0.00	$824	per sampling event
Nylon Tubing, 1/4" Outside Diameter	1625.00	LF	0.63	0.00	0.00	$1,024	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	4.00	WK	95.45	0.00	0.00	$382	
Flow Through Monitor, Weekly Rental	4.00	WK	323.68	0.00	0.00	$1,295	
Water Quality Parameter Testing Device	4.00	WK	344.33	0.00	0.00	$1,377	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	76.00	EA	47.87	0.00	0.00	$3,638	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	76.00	EA	37.11	0.00	0.00	$2,820	
Volatile Organic Analysis (EPA 624), Water Analysis	76.00	EA	296.90	0.00	0.00	$22,564	
Sulfate (EPA 300.0), Water Analysis	76.00	EA	27.94	0.00	0.00	$2,123	
Sulfide (EPA 376.1), Water Analysis	76.00	EA	40.89	0.00	0.00	$3,108	
Ferrous Iron (S.M. 3500 Fe - D)	76.00	EA	129.55	0.00	0.00	$9,846	
4" Submersible Pump Rental, Week	4.00	WK	329.12	0.00	0.00	$1,316	
SUBTOTAL						**$51,240**	
Groundwater Monitoring (Years 3, 4 and 5)							16 wells sampled semi-annually
Disposable Materials per Sample	38.00	EA	12.14	0.00	0.00	$461	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	38.00	EA	10.84	0.00	0.00	$412	per sampling event
Nylon Tubing, 1/4" Outside Diameter	812.50	LF	0.63	0.00	0.00	$512	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	2.00	WK	95.45	0.00	0.00	$191	
Flow Through Monitor, Weekly Rental	2.00	WK	323.68	0.00	0.00	$647	
Water Quality Parameter Testing Device	2.00	WK	344.33	0.00	0.00	$689	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	38.00	EA	47.87	0.00	0.00	$1,819	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	38.00	EA	37.11	0.00	0.00	$1,410	
Volatile Organic Analysis (EPA 624), Water Analysis	38.00	EA	296.90	0.00	0.00	$11,282	
Sulfate (EPA 300.0), Water Analysis	38.00	EA	27.94	0.00	0.00	$1,062	
Sulfide (EPA 376.1), Water Analysis	38.00	EA	40.89	0.00	0.00	$1,554	
Ferrous Iron (S.M. 3500 Fe - D)	38.00	EA	129.55	0.00	0.00	$4,923	
4" Submersible Pump Rental, Week	2.00	WK	329.12	0.00	0.00	$658	
SUBTOTAL						**$25,620**	
Groundwater Monitoring (Years 6 through 20)							16 wells sampled annually
Disposable Materials per Sample	19.00	EA	12.14	0.00	0.00	$231	inlcudes 2 QC and 1 equipment rinsate
Decontamination Materials per Sample	19.00	EA	10.84	0.00	0.00	$206	per sampling event
Nylon Tubing, 1/4" Outside Diameter	406.25	LF	0.63	0.00	0.00	$256	
Water Level Indicator, Manual, Polyethylene Tape, 100' Cable, Weekly Rental	1.00	WK	95.45	0.00	0.00	$95	
Flow Through Monitor, Weekly Rental	1.00	WK	323.68	0.00	0.00	$324	
Water Quality Parameter Testing Device	1.00	WK	344.33	0.00	0.00	$344	
Nitrogen/Nitrite/Nitrate (EPA 300.0/SM 4110B, Water Analysis	19.00	EA	47.87	0.00	0.00	$910	
Acidity/Alkalinity (EPA 305.1/310.1), Water Analysis	19.00	EA	37.11	0.00	0.00	$705	
Volatile Organic Analysis (EPA 624), Water Analysis	19.00	EA	296.90	0.00	0.00	$5,641	
Sulfate (EPA 300.0), Water Analysis	19.00	EA	27.94	0.00	0.00	$531	
Sulfide (EPA 376.1), Water Analysis	19.00	EA	40.89	0.00	0.00	$777	
Ferrous Iron (S.M. 3500 Fe - D)	19.00	EA	129.55	0.00	0.00	$2,461	
4" Submersible Pump Rental, Week	1.00	WK	329.12	0.00	0.00	$329	
SUBTOTAL						**$12,810**	
Surface Water Monitoring (Year 1)							
Glass Coliwasas, Disposable, 7/8" x 42", 200 ml, Case of 12	1.00	EA	121.96	0.00	0.00	$122	
Cyanide (EPA 335.2), Water Analysis	5.00	EA	76.79	0.00	0.00	$384	
Oil And Grease (EPA 413.2), Water Analysis	5.00	EA	89.07	0.00	0.00	$445	
Volatile Organic Analysis (EPA 624), Water Analysis	5.00	EA	296.90	0.00	0.00	$1,485	
TAL Metals (EPA 6010/7000s), Water, Water Analysis	5.00	EA	469.10	0.00	0.00	$2,346	
Mercury, Cold Vapor (EPA 245.1), Water Analysis	5.00	EA	64.78	0.00	0.00	$324	
SUBTOTAL						**$5,105**	

TABLE B-5 ALTERNATIVE 4 PUMP AND TREAT WITH AIR STRIPPING TOTAL REMEDIAL COST
Feasibility Study Report, SWMUs 2, 5, 7, and 18, Naval Weapons Station Seal Beach, Detachment Concord

COST ESTIMATE SUMMARY

Site: SWMUs 2, 5, 7, and 18
Location: Naval Weapons Station Seal Beach, Detachment Concord
Phase: Feasibility Study
Base Year: 2004
Date: December 10, 2004

Description: Treatment of vadose zone using soil vapor extraction and carbon adsorption. Pump and treat of contaminated groundwater (entire plume) by air stripping processes. Quarterly groundwater montitoring during first two years of active treatment. Semiannul groundwater sampling for 3 years, annual sampling for 15 years.Total remedial timeframe is 20 years.

DESCRIPTION	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Costa	Notes
Surface Water Monitoring (Years 2 though 20)							
Glass Coliwasas, Disposable, 7/8" x 42", 200 ml, Case of 12	1.00	EA	121.96	0.00	0.00	$122	
Cyanide (EPA 335.2), Water Analysis	2.00	EA	76.79	0.00	0.00	$154	
Oil And Grease (EPA 413.2), Water Analysis	2.00	EA	89.07	0.00	0.00	$178	
Volatile Organic Analysis (EPA 624), Water Analysis	2.00	EA	296.90	0.00	0.00	$594	
TAL Metals (EPA 6010/7000s), Water, Water Analysis	2.00	EA	469.10	0.00	0.00	$938	
Mercury, Cold Vapor (EPA 245.1), Water Analysis	2.00	EA	64.78	0.00	0.00	$130	
SUBTOTAL						**$2,115**	
General Monitoring (Years 1 and 2)							
Car or Van Mileage Charge	900.00	MI	0.52	0.00	0.00	$468	
Project Manager	4.00	HR	0.00	307.79	0.00	$1,231	
Project Engineer	30.00	HR	0.00	196.52	0.00	$5,896	
Project Scientist	382.00	HR	0.00	186.88	0.00	$71,388	
Staff Scientist	80.00	HR	0.00	153.23	0.00	$12,258	
Field Technician	170.00	HR	0.00	123.28	0.00	$20,958	
Word Processing/Clerical	50.00	HR	0.00	97.18	0.00	$4,859	
Draftsman/CADD	46.00	HR	0.00	127.43	0.00	$5,862	
SUBTOTAL						**$122,920**	
General Monitoring (Years 3, 4, and 5)							
Car or Van Mileage Charge	450.00	MI	0.52	0.00	0.00	$234	
Project Manager	4.00	HR	0.00	307.79	0.00	$1,231	
Project Engineer	15.00	HR	0.00	196.52	0.00	$2,948	
Project Scientist	205.00	HR	0.00	186.88	0.00	$38,310	
Staff Scientist	40.00	HR	0.00	153.23	0.00	$6,129	
Field Technician	85.00	HR	0.00	123.28	0.00	$10,479	
Word Processing/Clerical	25.00	HR	0.00	97.18	0.00	$2,430	
Draftsman/CADD	23.00	HR	0.00	127.43	0.00	$2,931	
SUBTOTAL						**$64,692**	
General Monitoring (Years 6 though 20)							
Car or Van Mileage Charge	225.00	MI	0.52	0.00	0.00	$117	
Project Manager	4.00	HR	0.00	307.79	0.00	$1,231	
Project Engineer	8.00	HR	0.00	196.52	0.00	$1,572	
Project Scientist	115.00	HR	0.00	186.88	0.00	$21,491	
Staff Scientist	20.00	HR	0.00	153.23	0.00	$3,065	
Field Technician	45.00	HR	0.00	123.28	0.00	$5,548	
Word Processing/Clerical	15.00	HR	0.00	97.18	0.00	$1,458	
Draftsman/CADD	15.00	HR	0.00	127.43	0.00	$1,911	
SUBTOTAL						**$36,393**	
SUBTOTAL (Year 1)						**$770,044**	
SUBTOTAL (Year 2)						**$767,054**	
SUBTOTAL (Years 3, 4 and 5)						**$681,091**	
SUBTOTAL (Years 6 through 20)						**$642,097**	

PERIODIC COSTS[a]:	Year	Quantity	Unit	Unit Cost	Extended Cost	Notes
Five Year review Report	5-15	3.00	EA	20710.05	$62,130	End of years 5, 10, 15
Contingency		0.25			$15,533	10% scope + 15% bid
SUBTOTAL					**$77,663**	
Close-out report	20	1.00	EA	21553.00	$21,553	Close out report
Well Abandonment	20	16.00	EA	837.00	$13,392	
Contingency		25%			$8,736	10% scope + 15% bid
SUBTOTAL					**$43,681**	

PRESENT VALUE ANALYSES:

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factorb,c	Present Value	Notes
Capital Cost	0	$1,046,460	$1,046,460	1.0000	$1,046,460	
Annual O&M	1	$770,044	$770,044	0.9690	$746,167	Year 1 monitoring
Annual O&M	2	$767,054	$767,054	0.9389	$720,222	Year 2 monitoring
Annual O&M	3-5	$2,043,273	$681,091	2.8178	$1,919,157	Years 3 through 5 monitoring
Annual O&M	6-20	$9,631,457	$642,097	11.1436	$7,155,275	Years 6 through 20 monitoring
Periodic Cost	5-15	$77,663	$25,888	2.3534	$60,924	Five-year reviews
Periodic Cost	20	$43,681	$43,681	0.5326	$23,265	Close-out report, well abandonment
		$14,379,632			**$11,671,471**	

TOTAL PRESENT VALUE OF ALTERNATIVE 4 **$11,671,471**

Notes:
a Costs provided by RACER 2004
b Discount factor = $\frac{1}{(1+i)^t}$ where i = 0.024 and t = year (i.e., the present value of the dollar paid in year t at2.4%)
c Multi-year discount factor = $\frac{(1+i)^n - 1}{i(1+i)^n}$ where i = 0.024 for a 20 year technology, t = year, and n = total number of years (i.e., the present value of the dollar paid per year from year 1 to year n at 2.4%)